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INTERRELATIONSHIP OF IN-SITU ROCK PROPERTIES, EXCAVATION METHOD, AND MUCK

H. F. Haller, et al

Holmes and Narver, Incorporated

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Semi-Annual Technical Report No. 1

# INTERRELATIONSHIP OF IN-SITU ROCK PROPERTIES, EXCAVATION METHOD, AND MUCK CHARACTERISTICS



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#### ADVANCED RESEARCH PROJECTS AGENCY

ARPA Order 1579, Amendment 3 Program Code No. 2F10

September 1972

Report Period February 16, 1972 - August 31, 1972

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Reports results of research to correlate the properties of in-situ rocks with materials handling properties of muck and parameters of excavation systems. Goals are to develop methods for predicting muck characteristics from collected data and for selection of transport equipment through the Muck Designation Number concept. Muck sample, rock, and operating data collection, testing methods, data processing, development of MDN's, preliminary regression analyses, and equipment selection are described.

Data available 8/31/72 from 50 samples at 23 sites (16 samples from 8 sites in 1972) is presented in raw data printout and narrative-graphic summary form, s'wing lithology, rock properties, operating data, and muck properties. Tentative MDN's are described by composite size and distribution curves, with preliminary regression analyses of 27 data sets and prediction accuracies of over 90 percent. Applications to equipment selection/design include input for design formulae used in mathematical models of belt and hydraulic conveying systems.

DOD implications include more rational transport equipment selection and design, with resultant speed and cost benefits. Recommended additional research includes sampling operations and formations not previously available, resampling to improve the confidence level of the data, dynamic testing for coefficients of rock strength in addition to current tests, and predictor refinements.

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by H. F. Haller H. C. Pattison Dr. O. C. Baldonado

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#### FOREWORD

This report presents the results of research performed during 1971 and 1972 into the interrelationships of in-situ rock properties and the characteristics of muck produced by various excavation methods. The authors wish to express their appreciation and that of Holmes & Narver, Inc., for the assistance provided by the many U. S. Bureau of Mines and Holmes & Narver staff members, as well as those individuals and organizations listed below who also participated in the program.

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#### INTRODUCTION AND SUMMARY

#### **PURPOSE**

The purpose of the program is to develop a method for predicting the materials handling properties of muck from the engineering properties of rock and the parameters of excavation systems, and a means of selecting the most suitable transportation equipment for the muck through the concept of Muck Designation Numbers (MDN's).

MDN's range in whole numbers from 1 through 7. MDN 1 describes muck with a large maximum piece size, more than 5 percent plus 6-inch material, and a predominant distribution in the plus 1/2-inch size range. The maximum size of MDN 7 is relatively small, the predominant distribution is minus 1/2 inch, and more than 20 percent is minus 200 mesh in size. Intermediate numbers range in size and size distribution between end points. The concept recognizes that muck characteristics vary with excavation methods as well as rock properties.

#### SCOPE

This report describes results of research performed in the first half of a contract initiated on February 16, 1972, for a 14-month period. The work is a continuation of a previous 12-month contract of which the results also are covered to summarize the total accomplished and the current status of the program.

#### CONCLUSIONS

Program activities have included sample and data collection, physical testing, data storage and processing, development of tentative MDN's, preliminary correlation with rock properties, and establishing the parameters of muck handling systems.

Regression analysis of seventeen sets of rock property, Raise Boring Machine (RBM), and Tunnel Boring Machine (TBM) data produced a predictor equation with an apparent accuracy over 90 percent. Analysis of 10 sets of rock data with conventional excavation parameters produced an accuracy of nearly 100 percent. Inclusion of additional data is expected to improve prediction reliability.

Predictor accuracy probably will not be maintained at preliminary levels, and appropriate parameters remain to be developed for shield and drag cutter TBM's. However, it can be concluded that MDN's are predictable within the limits of reasonable accuracy for the majority of rocks and methods sampled under the program.

Preliminary analysis also shows that MDN data can be used as input for design formulae and performance-cost models of belt and hydraulic conveying systems.

#### REFERENCE TO DETAILS

Details of the topics summarized below are arranged under the same headings in the report.

#### SUMMARY

#### 1. Technical Problems

Inadequate subsurface information on new tunnels limits the effectiveness of construction planning and forces contractors to base bids on methods and equipment which may not suit the job. Loss of time, lives, and money has often resulted.

Estimates of the volume of tunnel construction made several years ago focused attention on the importance of a more logical approach to methods and equipment selection. The advisability of increasing excavation speed while reducing costs has been reemphasized by recent studies which show that prior tunneling forecasts were conservative.

Muck transportation obviously is a major factor in tunnel cost; improvements would reduce tunnel costs significantly. Knowledge of the basic properties of a material is fundamental to improvement of handling techniques. Prior to the inception of the MDN program, however, practically no information had been collected on muck characteristics; and correlations between muck properties, the properties of the in situ rock, and the components of rapid excavation systems had not been established. These data are essential as a basis for optimum selection from the transportation systems in current use and for development of the high speed systems required in the future.

#### 2. General Methodology

The research plan is to collect muck samples, lithologic and operating data, and rock specimens, where necessary, from operating tunnels; determine muck characteristics and rock properties by physical testing; correlate and analyze rock and muck properties and quantify relationships through MDN's; and correlate rock and muck characteristics, MDN's, and the components of rapid excavation systems with muck transport system capabilities.

Lithologic data consists of descriptions of rocks, their classification by probable origin and subsequent alteration, and Rock Quality Designations (RQD's) which indicate the frequency of discontinuities. Operating data includes descriptions of the equipment and methods used in the total excavation system. Rock test data includes unconfined uniaxial compressive strength, dry unit weight, hardness, and stressstrain relationships known as Young's modulus and Poisson's ratio. Commercial muck test data includes size distribution, shape, moisture content, dry loose unit weight, and abrasiveness. Additional muck tests by the Pittsburgh Mining and Safety Research Center (PMSRC) determine Atterberg Limits, potential volume change, specific gravity, angles of repose, slide, and internal friction, apparent cohesion, and bulk density.

#### 3. Nechnical Results

#### 3.1 Site Selection

A list of current and scheduled tunnels, originally compiled to assure that program objectives could be met, has been revised periodically. The current list is included in Appendix A. Sites for data and sample collection were selected with emphasis on mechanical operations in hard rock. In the first year, some soft rock and conventional tunnels were included as examples of unusual advance rates and systems. In the current program, conventional operations in hard rock at deep mines have been sampled at client request.

#### 3.2 Sample and Data Collection

In the current program, operating data and sixteen muck samples were collected from eight sites. Totals for the program are 50 samples from 23 sites. Resampling at four sites confirmed the reliability of initial results. All other samples reflect differing lithologies, operating methods, or equipment.

Rock specimens for engineering property tests have been collected from 39 fermations at 21 sites. Nineteen of the specimens, some of which represent formations sampled in 1971, were collected from nine sites in 1972.

Two shield, two RBM, 18 conventional, and 28 TBM operations have been sampled to date. Rock types sampled include four classified as Very High Strength, 20 Kigh Strength, four Medium, 20 Low, and six Very Low Itrength. Those remaining to be tested are expected to include three High Strength, six Medium, and two Low Strength classifications. A basis for these classifications follows in the body of the report.

## 3.3 Physical Testing

Standard tests, approved by the American Society for. Testing Materials and/or the U. S. Bureau of Mines, were selected for use by commercial laboratories to ensure consistency of results.

Contracts to perform muck tests were negotiated with 18 commercial laboratories. Samples were delivered for testing and shipment of fractions to the U. S. Bureau of Mines, PMSRC, for additional tests. Under the current contract, the volume of the fractions has been increased from 2 to 4 cubic feet. At the end of the reporting period, muck tests by commercial laboratories had been reported on 46 sets of samples and on 41 sets by the PMSRC.

Contracts to perform rock tests have been negotiated with five commercial laboratories. One laboratory is now performing all rock tests. Of the 39 sets of rock specimens which have been collected, 31 test suites have been completed. Stress-strain data from testing initiated in 1972 was obtained on 11 rocks, including four sampled in 1971. Results from Schmidt hardness tests on rock cores, also initiated in 1972, have not been consistent. Modification of test methods is contemplated. Initial abrasiveness tests are planned for the third quarter of the contract.

# 3.4 Data Processing

Formats were developed for storage and printout of lithologic rock, muck, and tunnel data: data received to date has been stored on punch cards and printouts of these data are included as Appendix B. A form was developed for narrative and graphic presentation of data. These "System Data Sheets" are included as Appendix C.

#### 3.5 Development of MDN's

Size distribution curves from initial sampling varied distinctly, generally as had been expected; and an algorithm to correlate MDN's, in situ rock properties, and excavation methods was developed, as described in Appendix D.

Continued sample testing produced some curves which fit well with the initial curves, and others which required establishing additional categories. Using the data available at the end of the first year, curves of similar form were plotted together, and preliminary MDN's were assigned. The resulting composite curves are shown in gures 3-3 through 3-11.

Initial regression analyses produced the predictor equations described in the "Conclusions" section, indicating accuracies over 90 percent for RBM/TBM and for conventional operations. Computer input data are shown in Section 3, and the output tabulations are shown as Figures 3-1 and 3-2.

Additional iterations will be performed when the data collected in 1972 is in final form. Values for Young's modulus, Poisson's ratio, and Schmidt hardness resulting from current tests will be substituted for the less important parameters and inferred values used in current analyses. Current efforts to obtain data on net torque for TBM's and RBM's, and to develop operating parameters for drag cutter TBM and shield operations will be continued.

## 3.6 Transport System Selection

A list of equipment capabilities, system constraints, and MDN applications, prepared for the Annual Technical Report for the first year, has been included as Appendix E.

Belt and hydraulic conveying system design parameters and available parametric mathematical models of these systems were studied under the current program. Collected muck property data is appropriate as input to design formulae and the models. Some clarification of design parameters and refinement of the models is planned for the second half of the current program. An example of MDN data use in design of an hydraulic system is in progress; a comparison between an existing installation and a belt conveyor design based on MDN data, and examples of MDN applications to other systems are planned.

#### 4. DOD Implications

Data accumulated under the program are nonexistent elsewhere in rapid excavation technology and can provide a more rational basis for selection of materials handling systems for excavation methods in current use. These data will also be invaluable to the design of the equipment required to match the improved advance rates resulting from current excavation research. As alternatives to design of systems to handle a specific type of muck, MDN data can be used to select process equipment to change muck characteristics to suit a system, or to select separation and supplementary haulage equipment for the oversize fraction of muck which cannot be handled by a continuous system which is otherwise well adapted to a site.

The MDN program provides basic data required for a rational engineering approach to problem solutions in a most important subsystem of the rapid excavation process. It will show examples of data application and should be used to indicate the areas in which research and development of modifications or new methods would be most productive.

### 5. Implications for Further Research

#### 5.1 Sample and Data Collection

Recommendations for further research are based in part on the following projection of formations and excavation systems for which data is expected to be available at the end of the current contract.

	Rock Strength								
Excavation Method	Very High	High	Med- ium	Low	Very Low	Total			
Conventional Shield Machine	3 0	9	5 0	1 0	1 2	19 2			
Drag Cutters Disc Cutters	0 2	1 7	1 5	2	1	5			
Roller Cutters Combination	0	4	1	0	0	15 5			
Cutters	0	3	1	1	2	7			

To be consistent with good sampling and testing practice, data reliability should be confirmed by repetition of all single samples. Eleven sites previously sampled once are expected to be available in 1973. Statistically, the number of samples used in development of a predictor equation should be greater than the number of variables in the analysis. To improve prediction reliability additional samples, detailed in the body of the report, should be collected from all types of TBM's in selected formations.

To demonstrate variations in muck characteristics with rock properties, conventional and selected TBM samples should be collected from the Medium and Low Strength rocks.

To provide data on the full range of rock types, stratified volcanic and fine grained igneous rocks should be sampled. Sampling muck from tests of unusual rock breaking techniques which may become the standards of the future should be initiated to provide data on the muck for which transport systems will be required.

#### 5.2 Physical Testing

Continued development of testing methods to provide consistent results from Schmidt hardness tests is recommended because of the speed, low cost, and nondestructive nature of the only test for a dynamic rock property in current use.

Investigation of the Protodyakonov test for resistance to fragmentation is recommended to determine the effect of a second dynamic property on prediction accuracy.

#### 5.3 General

Potential improvements in systems components which require the application of techniques which are technically sound but not yet developed to a point of practical application may appear in the collection and analysis of program data. These should be identified as attractive areas for research and development.

# 6. Special Comments

A Schmidt impact rock test hammer and two self rescuers were purchased during the reporting period for use in the program. No invention has been made in the course of the work performed under this contract.

#### 1. TECHNICAL PROBLEMS

The effectiveness of planning for new tunnels has been limited by the quantity and quality of information concerning subsurface conditions which has been available. Owners and owner-agencies often have been reluctant to collect data on the properties of materials to be excavated, or to publish information which has been collected. Interested contractors are forced to base proposals on inadequate information about conditions to be encountered, and to base cost estimates on methods and equipment which may not be well suited for conditions as they exist. Generally, significant allowances are made both for contingencies which can be anticipated and for those which cannot be foreseen.

The importance of a more logical approach to selection of methods and equipment for tunneling became apparent when the volume of this work probable in the future was estimated several years ago; it has been reemphasized by more recent studies which indicate that prior estimates were conservative. Wider application of tunnel boring machines, which require rock property data for design, and of an engineering approach to ground support have influenced owner and agency policies to the extent that collection and dissemination of more and better quality exploratory information appears to be a current trend.

Progress has been made and is continuing in research to determine relationships between rock properties, drillability, excavation, and support requirements. Prior to inception of the program described in this report, practically no information had been collected on the characteristics of the muck produced by various excavation methods, and correlations between the engineering properties of rock, muck characteristics, and the components of excavation systems had not been established.

In the absence of muck characteristic data, an adequate basis for selection of optimum transportation methods and equipment does not exist, and tunneling progress and contrave been affected adversely. Muck data are also basic requirements for engineering the improvements to existing transport systems and the development of the new systems which will be necessary to keep pace with the higher rates of excavation predicted for the future.

#### 2. GENERAL METHODOLOGY

Objectives of the program are to develop a method for predicting materials handling properties of muck from the in-situ properties of rock and a means of selecting the most suitable transportation equipment for muck produced by various excavation systems. The major emphasis is on mechanical excavation of hard rock. However, some soft rock and conventional operations are included as examples of unusual advance rates, equipment, and operating methods.

The program plan is to collect muck samples and operating data from tunnels and mining projects in rock of known properties; collect specimens from sites where the in-situ properties are unknown; determine muck characteristics and rock properties by physical testing; correlate and analyze rock and muck properties and quantify relationships through the coucept of Muck Designation Numbers (MDN's); and to establish correlations between rock and muck characteristics, MDN's, the components of rapid excavation systems, and selection of muck transport equipment.

#### 3. TECHNICAL RESULTS

#### 3.1 SITE SELECTION

A list of operating and scheduled tunnels, prepared originally to assure that program objectives could be met, has been revised periodically. The latest revision is included as Appendix A. Six of the tunnels listed are expected to be completed in 1972. Letter inquiries inviting program participation by off-continent tunnel operators met with no response. These tunnels have been deleted from the list.

Tunnel contractors, although under no obligation to participate in the program, have been most cooperative. Operating mine cooperation has been equally good, although access usually requires more operator support, and the impact of economic conditions has reduced emphasis on research. Scheduling sampling and data collection on a strictly noninterference basis and full observance of safety requirements have been important in gaining operator acceptance.

Early planning assumed that one basis for site selection would be the availability of rock property data at specific sites. Experience proved that collection of these data is necessary from the majority of locations, and the program was modified to reflect this requirement.

In the first half of 1971, it became apparent that sampling tunnel operations in a wide range of rock strengths and excavation techniques would be necessary to demonstrate that muck characteristics vary distinctively with rock characteristics and operating methods. The program plan was modified to provide for data collection in the variety possible within the limits of time and availability, and additional funds were provided by contract modification to enlarge the scope of field sampling.

In the first year of the program, sites were selected to provide one-third of the samples from conventional excavation. In the current year seven conventional and nine mechanical operations have been sampled, and one more of each is expected in the second half of the year.

In response to a client request to obtain samples and data from conventional operations in strong rocks at maximum depth during 1972, sites were selected for field work in two quartzites at 7,094 feet and

6,110 feet, a phyllite at 6,200 feet, a quartz monzonite at 2,075 feet, a conglomerate at 3,960 feet, and a graywacke at 3,480 feet below the surface. At some sites, planned sampling of stronger rocks and/or at greater depths could not be accomplished because of site conditions.

#### 3. 2 SAMPLE AND DATA COLLECTION

Muck samples and operating data have been collected from 23 mine and tunnel sites. Of 50 samples, 11 were collected from sites visited only once. Resampling was done in similar formations at four sites to confirm the reliability of initial results. All other samples reflect differing lithologies, operating methods, or equipment.

The scope of collecting in-situ rock data has been greater than was anticipated originally, because formations encountered in most locations could not be correlated with the existing rock data. Rock specimens or cores have been collected for engineering property tests from 39 formations at 21 sites.

Two shield operations, two RBM, 18 conventional, and 28 TBM operations have been sampled to date. Rock types classified include four Very High, twenty High Strength, four Medium, five Low, and six Very Low Strength. Rocks which remain to be tested are expected to include three High Strength, six Medium, and two Low Strength classifications.

Nine of the sampled sites are no longer available for field work. Of the remaining sites, one is expected to complete excavation in October of 1972.

Early in the 1972 program a request was received from the Project Officer to increase the volume of samples provided for testing at the Pittsburgh Mining and Safety Research Center (PMSRC) from 2 to 4 cubic feet. Sampling and laboratory procedures were modified to comply with this request.

Muck samples collected are representative of the material as it reaches the transportation system. Muck produced mechanically normally is sampled as it leaves the conveyor which is integral with the machine. Conventional muck is sampled by channeling. Pieces which are too large for practical delivery to a laboratory are measured, and calculated weights in the various size ranges are added to adjust the screen test results. Rock specimens, or rock cores when available, are collected in sizes large enough to permit the preparation of six test specimens approximately 2-1/8 inches in diameter by 4-1/4 inches long.

Operating data in the first year of the program was collected in sufficient detail to permit inclusion of all of the components of the tunneling system in the analysis and selection of optimum transportation subsystems for specific MDN's and tunnel configurations. Experience in data analysis has indicated a need for more precise thrust, torque, and cutter data than was expected to be required for mechanical tunneling. In the current year, these data are being collected for most of the TBM operations sampled to date.

#### 3.3 PHYSICAL TESTING

Published test methods were reviewed in detail to ensure that tests performed by commercial laboratories would yield consistent results. The following American Society for Testing and Materials (ASTM) standard methods were selected as specifications in the first year of the program.

- C566-67: Total Moisture Content by Drying
- C136-67: Sieve or Screen Analysis of Fine and Coarse Aggregates
- C117-69: Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing
- C29-69: Unit Weight of Aggregate, Loose Weight Determination
- C170-50: Compressive Strength of Natural Building Stone

Specifications for the last test procedure were modified to provide for greater accuracy in specimen preparation so that results will be comparable to those reported by other rock property research programs.

Review of the data collected in the first year led to a decision to test rock specimens for deformation moduli in the current program to provide additional data for regression analyses. Following a review of test methods, ASTM Standard C170-50 was replaced by the following procedure, and additional standards were developed to conform with the practices followed by U. S. Bureau of Mines research centers in measuring strains.

D2938-71: Unconfined Compressive Strength of Rock Core Specimens

Results of hardness tests by the Shore scleroscope, a laboratory instrument which tests hardness by rebound, are available for only three of the rock formations sampled. Additional tests by this method were found to be beyond the scope of this study. Hardness testing by the Schmidt hammer, a portable device which also tests rebound hardness, is nondestructive and relatively inexpensive and was specified for inclusion in the 1972 program. A hammer was purchased for use in testing turnel walls and rock specimens.

Standard methods of testing abrasiveness were reviewed to determine the feasibility of collecting these lata from tests on muck samples. The standard ASTM tests were found to measure the resistance of the sample to abrasion, rather than the abrasive effect on other materials. The latter is the property of greater interest in materials handling, and a machine designed for such testing was located by the Project Officer at the PMSRC and will be available to the program in the second half of the current contract period.

Modification of the standard test procedure was found necessary in testing muck from some low strength rocks. Screen testing the samples in the natural state was performed prior to the standard tests to avoid distortion of the curves caused by the disintegration of material during the wash screening which normally precedes dry sieve analysis. Natural screen test results are identified and shown as dotted lines on the size distrib. On curves.

Contracts to perform muck tests have been negotiated with 18 commercial testing laboratories. Collected samples were delivered for testing and shipment of minus 2-inch fractions to the U. S. Bureau of Mines, PMSRC, for additional tests to be performed at this facility. At the end of the reporting period, tests by commercial laboratories had been reported on 46 sets and by the PMSRC on 41 sets of muck samples. One set of samples tested commercially was lost in transit to the PMSRC.

Contracts to perform tests on rock specimens have been negotiated with five commercial laboratories. One laboratory is now performing all rock tests, which assures uniformity of results, but also delays some tests when the volume of work is high. Two sets of specimens destroyed in preparation for testing in 1971 were replaced in 1972. A total of 39 sets of rock specimens have been collected, on which 31 reports have been received, and 8 sets remain to be tested. Stress-strain data was obtained on 11 rocks, including 4 collected in the 1971 program. Specimens yet to be tested appear to be of the necessary quality for stress-strain testing.

Initial Schmidt hardness tests by project personnel on walls of tunnels gave results which correlated well with those reported by other researchers on similar rocks. Initial tests on 11 core specimens showed no obvious correlation with field tests or with values obtained from the hardness-compressive strength relationships established by previous investigations. Further trials on hand lapped core specimens and a modified cradle indicated that lapping raised test values somewhat nearer those observed in tunnel wall tests. Some variation in values appears to be associated with core straightness. The cost and results of testing polished flat surfaces is being investigated.

#### 3.4 DATA PROCESSING

A format was developed for computer printout of lithologic, rock, muck, and tunnel data. Test results received to date have been stored on punch cards. Printouts of these raw data are included as Appendix B. Blank spaces on the printout indicate that data is not available on the date of the report.

Narrative and graphic summaries were prepared to combine these data with descriptions of the excavation systems from which rock and muck samples were taken, and are included as Appendix C. Rock strength classifications are based on uniaxial compressive strength, and conform with those proposed by D. U. Deere, et al., in the "Engineering Classification and Index Properties for Intact Rock," University of Illinois, 1966. These classifications are:

 Very High Strength
 Greater than 32,000 psi

 High Strength
 16,000 - 32,000 psi

 Medium Strength
 8,000 - 16,000 psi

 Low Strength
 4,000 - 8,000 psi

 Very Low Strength
 Less than 4,000 psi

Grain size classifications of igneous rocks, from A. Johannsen's "A Descriptive Petrology of Igneous Rocks," 1931, are used as follows:

Very Coarse - Above 3 cm
Coarse - 1 to 3 cm
Medium - 1 to 10 mm
Fine - Below 1 mm

From J. F. Kemp's "A Handbook of Rocks," 1950, sedimentary rocks of fragmental grains above 2 mm, are classified as conglomerates, while those below 2 mm in size are classified as sandstones or siltstones.

Symbols used to describe the shape of particles in the sample fractions between screen sizes are the following:

A	-	Angular	S -	Subangula
P	-	Platy		Rounded
E	<b>m</b> s	Elongated		Cubic
I		Irregular		Spheroid

The curves show the percentage of the total sample weight passing one screen size and retained on the next. Screen sizes below 1/2 inch were selected to provide openings which become progressively smaller by approximately 50 percent as shown below:

Screen Size	#4	#8	#16	#30	#50	#100	#200
Nominal Square Openings, Inches	0.187	0.094	0.047	0.023	0.012	0.006	0.003

The abbreviation NA is used to indicate that an item of data is not available.

### 3.5 DEVELOPMENT OF MDN'S

In accordance with the program plan, which provided for placing major emphasis on data collection during the first year, analysis of data and development of MDN's has been preliminary. As data first became available, test result; were reviewed to confirm the validity of the conceptual classification criteria. Based on a plan of classification by materials handling characteristics, the proposed designation system employed seven numbered categories in which to group excavation products by size and size distribution. Numbers were assigned in a progression from No. 1 for muck with a relatively large maximum piece size and a predominant distribution in the 1 inch to 200 mesh range to No. 7, in which the maximum size is relatively small and the predominant distribution is in the minus 50 mesh sizes. The concept also recognized that muck characteristics would vary with the excavation method and contemplated modifying the MDN's to distinguish between excavation techniques.

Initial field work was scheduled at sites where rock strengths varied over a wide range and which would provide examples of shield, machine, and conventional operations. The size distribution curves of the muck from these sites (Identification Numbers H-1, 5-1, CL-1, NAST-1, and SF-1, Appendix C), varied distinctly, in general accordance with the

criteria, except that the size range of the predominant distribution was somewhat higher than had been inferred.

Using the initial data as a guide, a preliminary algorithm was developed for data analysis to correlate MDN's, in-situ rock properties, and excavation methods. The quantitative relationship sought was a predictor equation, obtained by multiple regression of the physical property data obtained from the rock sample tests and a predictor equation for the MDN. A discussion of this technique is included as Appendix D.

During algorithm development, resampling at four of the original sites confirmed the distinctive shape of the size distribution curves. Sampling at other sites produced some curves which fit well into the original categories and others which were distinctive enough to suggest establishing additional categories. Using the data available at the end of the first year, curves of similar form were plotted together, and tentative designation numbers were assigned. The resultant composites are shown as Figures 3-3 through 3-11.

The "T" prefix was added to all MDN's to indicate the preliminary nature of the assignments. Parameters available for the analysis of all samples included values of uniaxial compressive strength ( $f_c$ ), rock quality designation (RQD), and dry unit weight (DUW) for which quantitative values were determined by field observation and testing. To avoid reducing data derivatives to extremely small values, rocks with compressive strengths of 1K psi or less have been assigned arbitrary strengths of 1. Rock classifications by origin were quantified as igneous = 1, metamorphic = 2, and sedimentary = 3; and ground water occurrence was quantified as dry = 1, minor = 2, and wet = 3. The order and magnitude of the number assignment is immaterial since these are modified in the analysis in nearly any case. Schmidt hardness values (H) are converted Shore values, where available, or inferred from data published by D. U. Deere, et al., in the "Engineering Classification and Index Properties for Intact Rock" referenced above.

Cutter spacing (CS) appeared to be an important TBM characteristic. Average dimensions were available for disc cutter and some drag cutter machines. For roller cutters for which no kerf pattern is apparent, values were obtained by dividing the body spacing by the number of buttons adjacent to a line along the face of the cutter and parallel to the axis of rotation. No kerf spacing was available for Alpine and Atlas-Copco TBM's. Net thrust values per square foot of face area (T) were available for TBM's with the same exceptions.

No appropriate operating parameters were available for the Alpine and Atlas-Copco machines or for the shield operations sampled, and the number of observations was insufficient to warrant analysis as a special case.

Parameters peculiar to conventional operations, face area per drill hole (A/H), and explosives per cubic yard excavated (PF) were calculated from collected data.

An initial analysis using rock properties alone led to a predictor equation for which the accuracy, described by the multiple correlation coefficient, was 72 percent. This was expected since operating parameters were not included. Seventeen sets of data were analyzed for machine operations using the values tabulated below:

	DA	TA FO	R ANAI	YSIS,	MAC	HINE (	PER	ATIO	JS	
Colum	n	1-	2	3	4	5	6	7	T 8	9
Ident.	Obs.	MDN	Class	fc	RQD		Н	GW	CS	T
5-1 7-2 LAW-2 LAW-3 LAW-4 MIL-1 MIL-2 QL-1 CL-1 NAST-2	1 2 3 4 5 6 7 8 9	2 2 3 3 4 4 4 5	3 3 3 3 3 3 2 2	22 22 19 19 19 36 36 11 9	92 92 100 100 100 85 85 30 10	166 160 160 160 166 166 165 174 167	49 49 42 42 42 50 50 37 45 55	1 1 1 1 1 2 2 2 2 2	0.20 0.20 0.20 0.20 0.16 0.18 0.09 0.09	3.56 2.91 4.28 4.28 3.76 6.09 6.09 3.53 5.09 3.89
NAST-4 LK-5	11 12	5 5	1	24	90	160	55	2	0.09	8.45
LK-6	13	5	1	32	92 86	165 137	55 50	1	0.24	4.46
NAST-1	14	5	1	18	90	167	55	1 2	0.13	17.20 3.89
LAY-1	15	6	3	10	84	150	47	1	0.24	2. 73
NAV-1	16	6	3	2	70	142	25	1	0.30	1.31
NAV-2	17	7	3	1	60	117	25	1	0.30	0.37

Results of stepwise regression, as shown in detail on Figure 3-1, following, indicate an accuracy of slightly more than 90 percent with a standard error of 0.8360 and the listed residuals.

```
MULTIPLE CORRELATION COEFFICIENT ..
                                               0.9081
F FOR ANALYSIS OF VAR. (D.F. =
                                               4.7026
STANDARD ERROR OF ESTIMATE ....
                                               0.8360
VARIABLE
                  REG. COEFF.
                                      STD. ERR-COEFF.
                                                          COMPUTED T
 5
                  -6.89554E-02
                                       3.55858E-02
                                                          -1.93772
 7
                   2.29717
                                       1.14621
                                                           2.00414
 2
                  -. 469846
                                       .381356
                                                          -1.23204
 8
                   17.7298
                                       11.4412
                                                           1.54964
 3
                  -6.63157E-02
                                       5.89690E-02
                                                          -1.12459
 6
                   .104435
                                       6.65627E-02
                                                           1.56898
 4
                  -6.17628E-03
                                       1.61827E-02
                                                          -.381659
9
                  -3.90019E-02
                                       .103588
                                                          -.376511
INTERCEPT (A)
               6.98974
```

TABLE OF	F RESIDUALS			
0ES.	Y OBSERVED	Y ESTIMATED	RESIDUAL	STD. RESID.
1	2.000	2.928	-0.928	-1.110
2	2.000	2.953	-0.953	-1.140
3	3.000	2.732	0.268	0.320
4	3.000	2.732	0.268	0.320
5	3.000	2.752	0.248	0.296
6	4.000	3.637	0.363	0.435
7	4.000	3.991	0.009	0.011
8	4.000	5.270	-1.270	-1.519
9	5.000	4.084	0.916	1.095
10	5.000	5.037	-0.037	-0.044
11	5.000	4.944	0.056	0.067
12	5.000	4.574	0.426	0.509
13	5.000	5.231	-0.231	-0.276
14	5.000	5.037	-0.037	-0.044
15	6.000	5.409	0.591	0.707
16	6.000	5.399	0.661	0.718
17	7.000	7.288	-0.288	-0.345

COMPUTER OUTPUT-TBM AND RBM DATA ANALYSIS.

FIGURE 3-1

Ten sets of data were analyzed for conventional operations, using the values tabulated below:

Colu	mn	FOR AN	2					EAA I		-
	_	1	2	3	4	5	6	7	8	9
Ident. No.	Obs.	MDN	Class	fc	RQD	DUW	Н	GW	A/H	PF
LK-l	1	1	1	25	83	162	55	1	5.4	4.0
LK-2	2	1	1	28	83	165	55	1	5.4	4.0
LK-3	3	1	2	26	80	178	50	1	5.0	5.0
LK-4	4	2	2	14	70	181	47	î	4.4	5.5
CA-1	5	3,	1	35	96	161	55	1	2.1	
11-3	6	3	3	22	90	152	43	1	5. 1	6.1
H-1	7	3	1	32	80	162	52	2		3.5
NAST-3	8	3	1	13	90	152	42		2.6	5.5
H-2	9	3	î	39	80	164	55	2	2.2	6.3
WNG-2	10	7	3	1	30	125	20	2	2.6	5. 6 5. 0

Results of the analysis, as shown in detail on Figure 3-2 following, indicate an accuracy of over 99 percent with a standard error of 0.2062 and the listed residuals.

Incorporation of additional data from subsequent field work and testing will improve the reliability of prediction, although it is doubtful that the accuracy indicated for conventional operations will be maintained at the level of the preliminary analysis. In additional iterations of the analysis, it is proposed to substitute values of Young's modulus and Poisson's ratio being accumulated in the current program for the less important parameters. Current efforts to obtain data on effective or net torque for TBM's, to develop appropriate parameters for analysis of the drag cutter TBM and shield MDN's, and to confirm inferred Schmidt hardness values will be continued to provide additional variables for analysis. Analyses with complete data are scheduled for the remainder of the current program.

## 3.6 TRANSPORT SYSTEM SELECTION

A list of equipment capabilities, system constraints, and MDN applications which comprised this section of the annual report of the first year's program is included as Appendix E.

```
MULTIPLE CORRELATION COEFFICIENT..... 0.9992
F FOR ANALYSIS OF VAR. (D.F. = 8. 1) 82.4711
STANDARD ERROR OF ESTIMATE..... 0.2062
```

VARIABLE	REG. COEFF.	STD. ERR-COEFF.	COMPUTED	T
5	-1.82976E-02	4.70338E-02	389031	
9	237584	•534353	444621	
2	.75977	.787339	.964985	
7	-1.37212	•48862	-2.80816	
4	-3.41264E-02	9.69424E-03	-3.52028	
8	879842	.801093	-1.0983	
3	-3.07083E-02	4.55421E-02	674285	
6	4.07791E-02	.147084	.277251	

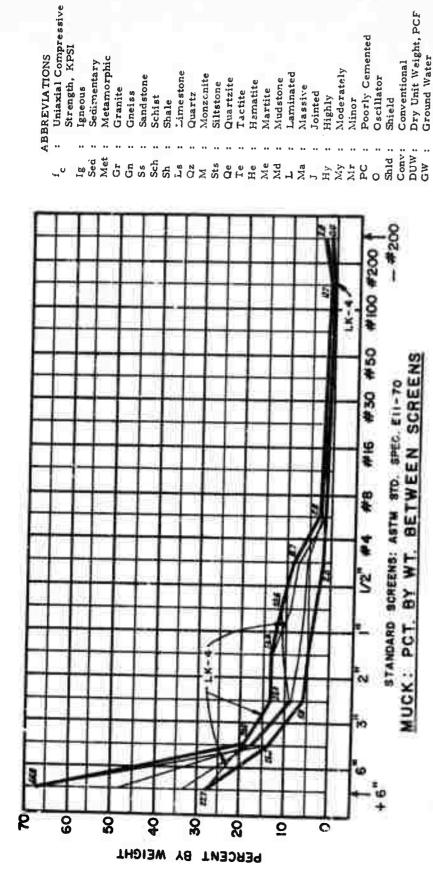
INTERCEPT (A) 15.7937

#### TABLE OF RESIDUALS

OBS. NO.	Y OBSERVED	Y ESTIMATED	RESIDUAL	STD. RESID.
1	1.000	1.065	-0.065	-0.318
2	1.000	0.918	0.082	0.395
3	1.000	1.069	-0.069	-0.336
4	2.000	1.954	0.046	155.0
5	3.000	3.013	-0.013	-0.065
6	3.000	2.983	0.017	0.080
,	3.000	3.115	-0.115	-0.558
8	3.000	2.978	0.022	0.109
9	3.000	2.898	0.102	0.495
10	7.000	7.005	-0.005	-0.022

COMPUTER OUTPUT-CONVENTIONAL DATA ANALYSIS.

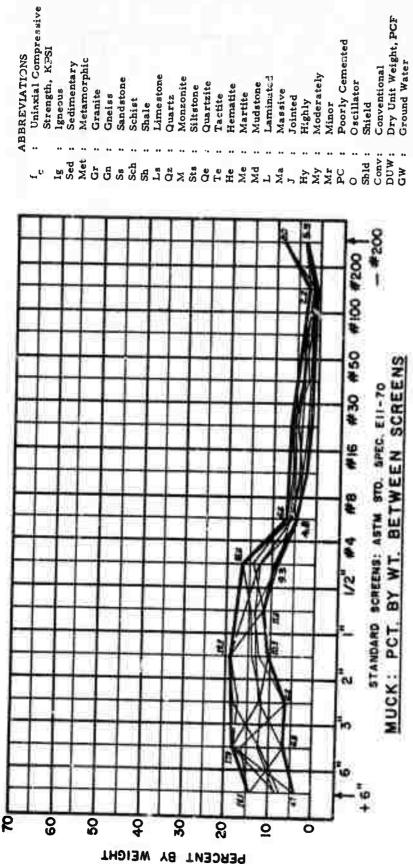
#### FIGURE 3-2



IDENT	FXCAV													
C IX					ROCK PROPERTIES	OPER	TIES			TIMMET		1 00		
3	METHOD	MON	CLASS	TYPE	STRUCT	,		WITTE	LIA DINITION		։	SQ. F.I. / EXPL.	EXPL.	MAX. SIZE
	,							2	THE DOWN HARDINESS	SIZE, FT.	80	HOLE	#/CY.	OBSERVED
1-V-1	Conv	I-1	Ig=1	O2 M	Mr J	25	83	162	55	10 m 110 t				
LK-2	Conv	+	12-1				┱			OI W MOI	Dry=1	4.0	4.0	4'x 3 x 2'
		,	1-8-1	Z Z	MrJ	25	83	165	n,	18W × 16	-			
LK-3	Conv	1.1	Mat. 2	1						2 4	1-617	† n	a.	3-1/2'x 2'x 2'
			7-12TAT	Ac ie	LWY	92	80	178	20	16W × 14 = D	1	4	,	
LK-4	Cont	4	1404-2	f	:					C * 1 T *	Dry=1	0.0	۰, ٥	2-1/2'x 1'x $1/2$ '
		7-1	7=12 int	T e	My J	14	20	181	47	15W × 14	ויייים			
											∠. y−1	4.4	0.0	27"x 18"x 12"
							+							
COL. NO	4						†	1						
		-	7			3	4	2	9		,	,		
												×	6	

\*\*Regression Data List. \*Inferred from D. U. Deere, et al, AD 646 610-1966.

AND MUCK DATA, MDN T-1 AND T-2, CONVENTIONAL OPERATING, TUNNEL, FIGURE 3-3: ROCK.

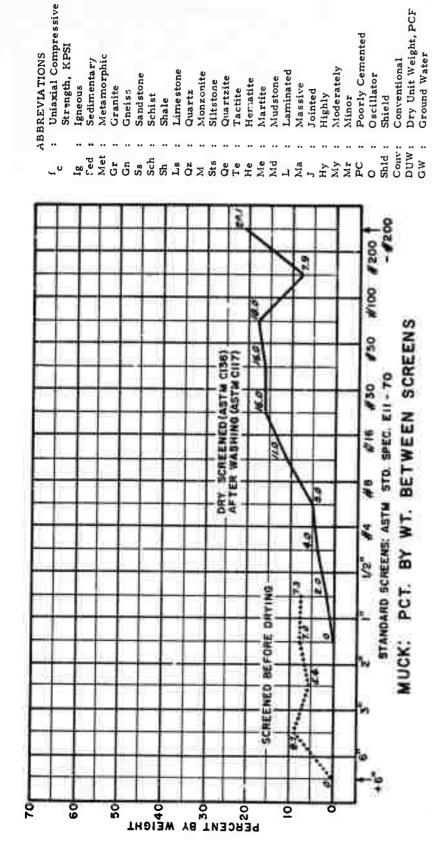


THENT	_														
NO	_				ROCK PROPERTIES	ROPE	RTIES			THUNDE	1.4	50 57	n. n. n.		Г
	METHOD MDN	MUN	CLASS	TYPE	STRUCT.	τ C	_	DUW	ROD DUW HARDNESS#	SIZE	M.C.	7.5 1.7	·		
GA-1	Conv	T-3	1g=1	Gr	Mr. I	35	70	:		4	,	TIONE	#/CI:	OBSERVED	-
11 2	,						2	101	25	10 x 10	Dry=1	2.1	٠ <u>,</u> 1	2-1/2'x 2'x 1'	_
	Conv	1-3	Sed= 3	Sts Sh	Ma Mr L 22	22	90	152	43	24W ~ 7 E					T
н.	Conu	4	-							C . I V	Dry=1	1.0	3,5	18"x 18" x 4"	-
		2	18= 1	5	Mr J	32	80	162	52	10 × 10	M=-2	1,6			T
NAST-3	Copy	T. 3	[-0]	,							7-11A7	6.0	٠, ٢	3'x 2'x 1'	-
			18-1	5	Mr	13	96	152	42	16W × 10	Mr2	, ,			Т
H-2	Conv	T-3	[0=]	-0-5		3						2.5	0.5	2-1/2× $1-1/2$ × $1$	-
				5	MIJ	39	80	164	55	10 x 10	Mr=2	2.6	7 5	21 - 1 - 1 - 1	T
													2	1 X.7/1-1 x.7	
															_
															-
					i										T
COL. NO.	상상		^			[								,	
						7	4	'n	9		r	0			т
												0	<b>-</b>		-

\*\*Regression Data List. "Inferred from D. U. Deere, et al, AD 646 610-1966.

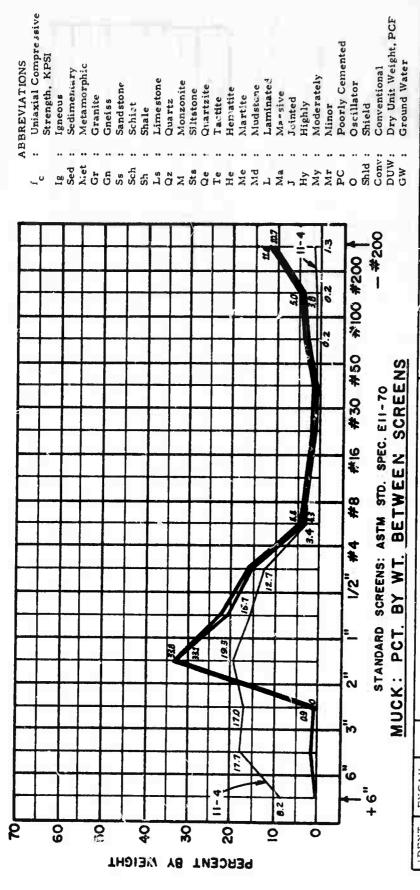
FIGURE 3-4: ROCK, TUNNEL, OPERATING, AND MUCK DATA, MDN T-3, CONVENTIONAL

3-13



TNEGI	EXCAV													
					ROCK FROPERTIES	ROPI	TRTIES			TUNNEL	EI.	CO ET	SO ET / EVD!	11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
INC.	MEIHOD MDN CLASS TYPE	MDN	CLASS	TYPE	STRUCT.	ĵ,	RQD	DUW	DUW HARDNESS*	SIZE, FT.	Μ̈́O	HOLF #/CV	#/CV	MAY. SIZE
WNG-2	Conv	T-7	Sed=3	Ss	PC	_	8	125	20	o = M				OBSERVED
									2	2 W X 7	wet=3	5.5	5.0	18"x 10"x . "
					_									
						1								
								1						
COL. NO. **	***	_	,			١								
			,			,	ų,	2	9		7	00	6	
Inferred	slnferred from D. U. Deere, et al, AD 646 610-1966.	. Deer	e, et al,	AD 646 6	10-1966.		*	Repres	**Regression Data List					
									TOTAL PARK TIPE					

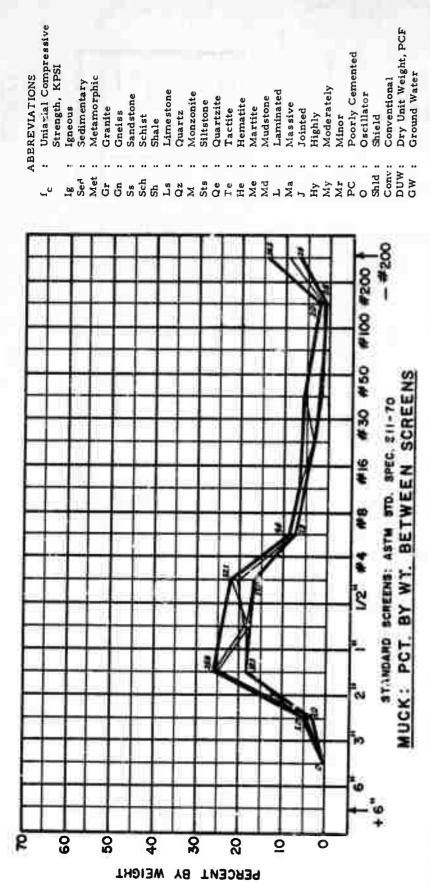
OPERATING, AND MUCK DATA, MDN T-?, CONVENTIONAL TUNNEL, FIGURE 3-5: ROCK,



IDENT.					ROCK PROPERTIES	OPER	TIES			THUNK	1,1	KEDE	Tito item	2100
NC.	METHOD MDN	NDN	CLASS TYPE		STRUCI.	ر	ROD	DUW	ROD DUW HARDNESS*	SIZE,	₩ S	SPACE	SPACE /SQ.FT.	OBSERVED
T	TBM	I-1	Sed= 3	ats Sh	Ma Mr L	22	06	99!	43	18W x 8.5	Dry=1	NA	NA	8"x 8"x 4"
ić.	TBM	T-2	Sed= 3	SS	Ma	22	45	166	49	18.08 dia. Dry=1	Drv=1		3.56K	3.56K 2-1/2" 8" 3/4"
7-2	TBM	T-2	Sed=3	Ss	Ma	22	26	166	49	18.08 dia.	Dry=1		2.91K	3"x 9"x 1"
						T								
COL. NO. 38	**		2			3	4	'n	9		7	8	6	
Informor	Information II I There are A D Care South	1,000	1	4	,,0101)		1							

Inferred from D. U. Deere, et al, AD 640 610-1966. \*\*Regression Data List.

OPERATING, AND MUCK DATA, MDN T-1 AND T-2, MACHINE FIGURE 3-6: ROCK, TUNNEL,



TODE TUBLICA	ΑĎ	Drv=1 0.20 4.28 3	Drv=1 0 20 4 28	Dry=1 0 20 2 26	200			6 8 2	
TINNET	SIZE, FT.	13.67 dia.	13.67 dia.	13. 67 dia.					
	ROD DUW HARDNESS* SIZE, FT.	42	42	42				9	C C
	MOQ	160	160	160				2	
RTIES	RQD	100	100	100				4	100
ROPE	Ţ	19	19	19				3	
ROCK PROPERTIES	STRUCT.	Ma	Ma	Ma					770 1015
	TYPE ST	Ls	Ls	Ls					AD 646
	MDN CLASS	Sed=3	Sed=3	Sed=3				2	o to
	NDN	T-3	I-3	I-3			T	-	Deer
EXCAV.	METHOD	TBM	TBN:	TBM				***	"Inferred from D. U. Deere et al AD 646 610-1922
IDENT.	000	LAW-2	LAW-3	LAW-4				COL. NO. **	Hinferred

AND MUCK DATA, MDN T-3, MACHINE OPERATING, TUNNFL, ROCK, FIGURE 3-7:

					-	ă	A	N N	OI WI. DEIWEEN SCREENS	တျ			 MO	Ground Water
IDENT.	EXCAV.				ROCK PROPERTIES	NO DE	RTIES							
o N	METHON MAN	XCX								LONNEL	1	KERF	THRIGHT	_
	20	NI TIME	CLASS		IYPE STRUCT.	٠,٠	ROD	MOO	DUW HARDNFSS* SIZE, FT.	SIZE. FT.	à S	SPACE	SDACE /CO ET	
MIL-1	TBM	T-4	Sed=3	Ls	Mv J	, ,,	8.	77.				7	1 34.5	OBSERVED
2 1174	Tal						3	700	00	11.17 dia.   Mr=2	Mr=2	0.16	60.9	2"x 1"x 1/2"
1	TNG ₹	1-4	Sed=3	Ls	My J	36	85	166	50	11.17 dia Ma-2	Ma,	0.0		
01-1	TBM	7-4	1104-2				+			a Tr	7-11A	0.10	60 .9	3"x 2"x 1/2"
			7=12TAT	Scn	1	7	30	165	37	11 dia.	Mr=2	01.0	2 53	
												0:10	2.53	2.x 1.x 1/2
COL. NO. ##	. * * . 0	_	2			,	,	1.			1			
						,	+	0	٥		7	00	•	

\*\*. Regression Data List.

OPERATING, AND MUCK DATA, MDN T-4, MACHINE

FIGURE 3-8: ROCK, TUNNEL,

0

Poorly Cemented

Oscillator

Shield

Shld:

- #200

#100 #200

#30 #50

**\***16

#8

. 2

STANDARD SCREENS: ASTM STD. SPEC. E11-70

Moderately

Laminated

Massive

Jointed Highly Minor

Hematite Martite Mudstone

OE

Uniaxial Compressive

ABBREVIATIONS

ē

9

20

8

8

PERCENT BY WEIGHT

8

9

Strength, KPSI Igneous

Metamorphic Sedimentary

Granite Gneiss Schist

Shale Limestone

Monzonite

Quartz

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FIGURE 3-9: ROCK, TUNNEL, OPERATING, AND MUCK DATA, MDN T-5, MACHINE AND SHIELD

SNC	Unianal Compressive Strength, KPSI	ry	hic											_	Poorly Cemented Oscillator Shield	lal
ABBREVIATIONS	Unianal Compi Strength, KPSI	Igneous Sedimentary	Metamorphic	Gneiss	Schist	Shale Limestone	Quartz	Siltstone	Quartzite Tactite	Hematite Martite	Mudstone	Massive	ited	Moderately	Poorly Cer Oscillator Shield	Conventional
BBRE	Str	Sed	Med C	Š	Schist	Shale	Qua	Silt	Qua	Hen Mar	Muc	Mas	Jointed Highly	Moder	Poorly Oscilla Shield	S C
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		9-I	Sed=3	Md	Ma	=	96	144	40	10W x 9	Dry=1	NA	AN	36"x 14"x 8"
MB-1 TBM	TBM-0	I-6	Met=2	He Me	LHyJ	7	10	207	28	9.96 dia.	Drv=1	NA AN	NA AN	212 1-1/212 811
LAY-1 TBM		J-6	Sed=3	Ss	Ma	10	84	150	47	12.92 dia. Dry=1	Dry=1	0.24	2.73	4"x 4"x 1/2"
NAV-1 TBM		J-6	Sed=3	Sts	Ma	2	20	142	25	20.5 dia.	Dry=1	0.30	1 21	6112 E112 311
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COL. NO. **		_	2			3	4	2	9		7	80	6	

\*Inferred from D. U. Deere, et al, AD 646 610-1966. \*\*Regression Data List.

FIGURE 3-10: ROCK, TUNNEL, OPERATING, AND MUCK DATA, MDN T-6, MACHINE

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FIGURE 3-11: ROCK, TUNNEL, OPERATING, AND MUCK DATA, MDN T-7, MACHINE AND SHIELD

Belt conveyor and hydraulic transportation parameters have been studied under the current program. Standard belt conveyor design publications and available literature on hydraulic conveying were reviewed to determine the data required and the methods used in system designs.

The parametric mathematical models described in HN-8080 "Materials Handling for Tunnels," referenced in Appendix E, were reviewed for application in this study. It is apparent that muck size and size distribution, on which MDN's are based, as well as other physical property characteristics determined in the program can be used as input for the design formulae and the models.

Modification and refinement of the models, originally developed for the high advance rates of the future, will be necessary for direct application to current operations. Some design parameters are not well defined in the references, and further study will be necessary to resolve differences in design philosophy which appear in the literature.

A preliminary design of a hydraulic muck disposal system based on data from a TBM tunnel is in process. Comparison between a design based on study data and an extensive suspended conveyor installation is planned. One example of MDN application to each of the other transport systems will be provided.

### 4. DOD IMPLICATIONS

The data accumulated under the program are nonexistent in usable form elsewhere. While some TBM manufacturers and operators use muck size as an indicator of cutter efficiency, changes are noted during informal inspections at the machine and are seldom recorded except as showing a need for cutter replacement. A few screen analyses have been run, but results normally are not made available outside of a manufacturer's or contractor's organization.

Current selection of transportation systems usually is based on availability, intuition, and contractor familiarity with the equipment used at other sites. In some cases, the choice has been completely unsuitable for the muck produced. This has resulted in delays and additional expense which may be avoided by use of the information collected by the MDN study.

Previous investigations have indicated that major modifications of conventional equipment, or design of completely new systems, will be necessary to dispose of the muck from the high speed excavation systems predicted for the future. Muck characteristic data is a requisite as a basis for the engineering design of such system improvements or of innovative systems.

As an alternate to the design of a haulage system suitable for handling a particular muck, it may be practical to change muck characteristics at the face to provide a suitable feed for a handling system particularly well adapted to the tunnel site. MDN data will be invaluable to the selection of the necessary processing equipment.

A second alternate is in providing a continuous transport system such as hydraulic or pneumatic for the major volume of the muck, and temporary storage, as in a trailer or muck car, for a minor quantity of oversize which would be handled periodically. Again, muck characteristic data is a necessity to design the separation equipment and to estimate the capacity required in the secondary system.

In the course of the current program and subsequent use of the data produced, it is probable that potential improvements in transportation systems will appear. Where such improvements require the application of techniques which are technically sound but not developed to a point of practical application, they will be identified as attractive areas for research.

In summary, the current MDN program provides the basic data required for a rational, engineering approach to problem solutions in a most important subsystem of the rapid excavation process. It will show examples of data application and should be used to indicate the areas in which research and development of modifications or new methods would be most productive.

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## 5. IMPLICATIONS FOR FURTHER RESEARCH

### 5.1 SAMPLE AND DATA COLLECTION

At the end of the current contract, it is expected that the following samples will have been collected, including 19 in 1972 and 1 collected but not tested in the 1971 program.

		R	ock Stren	gth		
Excavation Method	Very High	High	Medium		Very Low	Total
Conventional Shield	3 0	9	5 0	1	1 2	19
Machine Drag Cutters	0	1	1	2	1	5
Disc Cutters Roller Cutters	0	7	5 1	1 0	0	15 5
Combination Cutters	0	3	1	1	2	7

At completion, the current program will have produced samples from 11 operations and/or formations which have not been sampled previously and which will be available for additional field work. To conform to good sampling and testing practice, the reliability of the data should be confirmed by repetition, preferably of all single tests.

While the major interest of the program is in strong rocks, variations in muck characteristics with strength can only be demonstrated by sampling the full range of rock strengths excavated by any one method. As they are available, additional sites should be sampled in formations of varied strength, such as the fine grained igneous and volcanic rocks.

Statistically, the number of samples used in developing a predictor equation should be greater than the number of the variables used in the analysis. Because the reliability of prediction is of major importance, additional samples should be obtained in the following operations.

1. Drag Cutter Machine excavation in High, Medium, and Low Strength rocks. These samples would provide a confirming data set in each strength category, and a total number of samples larger than the number of variables.

- 2. Roller Cutter Machine tunneling to provide enough data to analyze this method by a separate regression.
- Combination Cutter Machine excavation in Low Strength rock to confirm data from a single sample collected previously.
- 4. Conventional tunneling in Low and Very Low Strength rocks to confirm data from single samples collected previously.
- 5. Disc Cutter Machine tunneling in Low Strength formations to improve the spread of the data on this method.
- 6. Disc Cutter Machine tunneling with tungsten carbide button insert cutters as a promising development in machine excavation of strong rocks.

#### 5.2 PHYSICAL TESTING

Although problems have been encuntered in obtaining consistent results from Schmidt hardness tests on core samples, development of test methods should continue because it is the only fast and inexpensive known test to measure the property of rocks.

Abrasiveness testing should be initiated as soon as possible and continued within the limit of available funds to provide data for the cost analysis phase of equipment selection.

The modified Protodyakonov test for resistance to fragmentation should be investigated for effectiveness and cost to evaluate development of data on this rock property for use in regression analysis and prediction of MDN's.

### 5.3 INNOVATIVE TECHNIQUES

Unusual rock breaking techniques now under development, such as the electron beam, the water cannon, the conical borer, and continuous application of explosives may become standard practice in the future. Sampling muck from tests of these methods whenever possible is recommended.

#### 6. SPECIAL COMMENTS

A Schmidt rebound hardness tester and two MSA self-rescuers were purchased for use in the current program. No invention has been made in the course of the work performed under this contract.

## GLOSSARY

ASTM	American Society for	PF	Powder Factor
	Testing and	PMSRC	Pittsburgh Mining
	Materials		and Safety
BM	Beam		Research Center
CFM	Cubic feet per minute	POT.	Potential
CNTR	Center	PSF	Pounds per square foot
COMPR.	Compressed	PSI	Pounds per
CONTIN.	Continuous		square inch
CONV	Conveyor	Rect.	Rectangular
CY	Cubic Yard	REG.	Regular
DEG.	Degrees	RBM	Raise Boring Machine
DIA.	Diameter	RPM	Revolutions per Minute
DUW	Dry Unit Weight	RQD	Rock Quality
Est, (E)	Estimated		Designation
FWD	Four Wheel Drive	SF	Square Foot
GPM	Gallons per Minute	ST	Scoop Tram
HP	Horse Power	SPECIF.	Specific
HRS.	Hours	STRNTH.	Strength
IN.	Inch	TBM	Tunnel Boring
INTEG	Integral		Machine
Inter.	Internal	TC	Tungsten Carbide
K	Thousand	TCB	Tungsten Carbide
LBS, #	Pounds		Button
LHD	Load Haul Dump	Т	Tentative
LT	Long Ton	т.	Ton
MDN	Muck Designation	V	Volc
	Number	VOL	Volume
MAX	Maximum	w/	With
Moist.	Moisture	WT.	Weight
MM	Millimeter	I	Foot
NA.	Not Available	11	Inch
NO.	Number	#	Number
PCF	Pounds per	%	Percent
	Cubic Foot	(+)	Plus
PCT	Percent	(-)	Minus

#### APPENDIX A

#### TUNNEL PROJECTS

Compiled by Holmes & Narver, Inc., Anaheim, California, under U. S. Bureau of Mines Contract H0220023. Revised September 1, 1972

#### NORTH AMERICAN CONTINENT

Project and Location	Owner or Agency	Size	Length	Contractor
Lakeshore Mine Casa Grande, Arizona	Hecla Mining Co. El Paso Natural Gas	14'x14' 14'x18' Plus Level Development	7,500'	Hecla Mining Company Own Force

The two 7,500' headings, declines at a minus 15°, are nearing completion. Levels are being developed at 900' and 1,400' vertically below the portal. Formations include mylonite, quartzite, tactite, and quartz monzonite. A raise boring machine has started a series of holes to the development levels.

Superior Mine	Magma Copper	10'x10'	Various	Own Force
Superior,	Company			
Arizona				

Drifting on five levels to connect existing workings with a new shaft, now within 300' of completion at 4,200' depth. Formations are cretaceous conglomerate 7K to 10K psi, limestone 7K psi, quartzite to 20K psi. Operations are conventional.

San Manuel Mine	Magma Copper	12'x12'	Various	Own Force
San Manuel,	Company			
Arizona				

Main level drifting on two levels in quartz monzonite and monzonite porphyry, concurrent with shaft sinking to 3,700' depth. A 9,000' drift is planned to explore a new ore body from the bottom level of the new shaft.

Tonner	The Metropolitan	11'6''	#1 - 4,5891	Shea
#1 and #2	Water District of	Diameter	#2 -19, 360'	Construction
Brea, Calif.	Southern Calif.			Company

A Calweld machine is being assembled at the site to bore low strength sandstone and siltstone. Geologic data and cores are available from the owner agency.

Project and Location	Owner or Agency	_Size_	Lengti.	Contractor
Hunter Tunnel Fryingpan Project Merideth, Colorado	U.S. Bureau of Reclamation Denver, Colorado	10'x10'	4.4 Miles	Granite Construction Company

A conventional operation in formations similar to the Nast tunnel. Lithologic and engineering property data have been collected from the U. S. Bureau of Reclamation. Excavation is scheduled for completion in October, 1972.

Nast Tunnel Fryingpan Project Merideth,	_	10' Diameter	3 Miles	Peter Kiewit Sons
Colorado	Denver, Colorado			Company

A Wirth boring machine has been replaced by conventional drifting in fault zones, and is scheduled to resume work in more competent rock in November, 1972. Formations are predominantly granite, granite gneiss, granite porphyry, and granodiorite with compressive strengths from 18K to 24K psi. Rock is highly sheared in zones from a few feet to 400' thick.

Foggy Bottom Rosslyn Tunnel Section C-4 Washington, D.C.	WMATA Washington, D. C.	16'8'' Diameter Finished		Shea-Ball- S&M Construction J. V.
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Excavation by conventional methods in gneiss under the Potomac River. The schistose rock structure is reported to result in high shear strength and low compressive strength. Lithologic and engineering property data has been collected from the WMATA.

Osburne, Idaho  Crescent Mine  Bunker Hill  Company  Kellogg, Idaho	101x101	Various	Own Force
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Conventional drifting on several levels. Trackless equipment is used on the lowest level, at 6,100' depth in quartzite, from which a lower level will be developed by a decline. The USBM Spokane Mining Research Center has collected voluminous rock property data at this site.

Project and Location	Owner or Agency	Size	Length	Contractor
Star Mine Burke, Idaho	Hecla Mining Company, Wallace, Idaho	9'x10'	Various	Own Force

Conventional drifting on several levels. Rail mounted equipment is in use on the lowest level, at 7,094' depth, in quartzite.

Mt. Greenwood Dept. of Public 10'4"  Tunnel Works, City of Diameter Chicago, Chicago, Illinois Illinois	1.8 Miles	S. A. Healy Construction Company
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A Robbins machine has finished Mt. Greenwood No. 1. Preparations are in progress to start Mt. Greenwood No. 2 in limestone, reported similar to that in the Mt. Greenwood No. 1. Geologic and rock data has been collected from the owner agency.

White Pine Copper Company White Pine, Michigan	Copper Range Company New York, New York	18'1'' Diameter 18'x8-1/2' Rectangular	Various	Tunneling by White Pine With Own Force
		- To Ctaing drai		Own Force

A Robbins machine, operating in sandstone since 1969, has passed through a conglomerate horizon into the overlying shale. An Atlas-Copco machine is operating in the shale. Normal drifting is conventional. Existing rock property data includes compression, Prazilian tensile, and Shore hardness test results.

Site Mercury, Since Nevada (	USAEC and Defense Atomic Support Agency (DASA) Mercury, Nevada	Various		Reynolds Electrical and Engineering Company
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Conventional and Alpine Miner tunnels may provide an opportunity for comparison of the muck produced by the two systems. Formations are volcanic tuffs which vary from 600 to 4,500 psi in unconfined compressive strength. Engineering property data has been collected by the U. S. Geological Survey and by DASA.

Project and Location	Owner or Agency	Size	Length	Contractor
Navajo Irrigation Project Farmington, New Mexico	U.S. Bureau of Reclamation Denver, Colorado	20.5' Diameter	3 Miles	Fluor-Utah Engineering & Construction Company

A Dresser boring machine is operating in sandstone with an unconfined compressive strength of less than 1K psi, and is expected to reach a 9.7K psi sandstone as the tunnel advances.

Completion is scheduled for November, 1972.

Section 35	Kerr-McGee	10'x10'	Various	Kerr-McGee
Uranium Mine	Corporation	and		Own Force
Grants (Ambrosia		8'x8'		
Lake),				
New Mexico				

An Alpine Miner is operating in sandstone development headings, in which normal operations are conventional.

Kermac Potash	Kerr-lcGee	13'x5'	Various	Own Force
Carlsbad,	Corporation			
New Mexico				

Goodman continuous miners are operating in salt-potash formations reported from 3K to 6K psi in strength.

Cross-	Dept. of Public	18'4"	5-1/2	Tunnel
Irondequoit	Works,	Diameter	Miles	Constructors
Interceptor Tur	inel, Rochester,			(Greenfield-
Rochester,	New York			Ferrera-
New York				S.A. Healy,
				J. V.)

A Lawrence TBM is operating in formations reported as shale, limestone, and sandstone, compressive strengths 2K to 20K psi. Geologic and rock data has been collected from the owner agency.

Project and Location	Owner or Agency	Size	Length	Contractor
New York City, New York Contract #13	Dept. of Public Works, New York, New York	11'6'' and 8'6''	9, 2001	Perini-B&R-G.H. Ball-S&M Constructors, J. V.

Two Jarva TBM's are operating in mica schist, with compressive strength reported 15K to 30K psi. Cores and rock test data are available from the owner.

Homestake Mine, Lead, South Dakota	Homestake Mining Company	7-1/2'x 8-1/2'	Various	Own Force
------------------------------------	--------------------------	-------------------	---------	-----------

Conventional main level development drifting at 150' vertical intervals to 7,100' depth in phyllites, quartz mica schists, quartzites, carbonates and silicates, ranging in strength from 5K to 40K psi.

Cross Town Wastewater	City of Austin, Texas	9' Diameter	27, 300'	Granite
Interceptor		10'	30,500'	Constr. Co. Peter Kiewit &
Austin, Texas		Diameter		Sons Company

A Calweld machine will bore 30,500' in clays and limestones. A Robbins machine will bore 27,300' in limestones. Geologic and test data has been provided by the City of Austin.

Currant and Layout Tunnels Strawberry Aqueduct Heber City Utab	U.S. Bureau of Reclamation Denver, Colorado	10'4" Diameter	Length	S. A. Healy Construction Company
--	---	-------------------	--------	--

The Layout tunnel has been completed. A Robbins boring machine has started the Currant tunnel in conglomerate. Existing logs of drill holes show lithology. Compressive strength test results, from 14K psi to over 38K psi in the conglomerate, have been provided by the Bureau of Reclamation.

Project and	Owner			Control of the second
Location	or Agency	Size	Length	Contractor
Golden Goose II	Western Nuclear,	8' x 10'	Develop-	Owner
Uranium Mine	Inc.		ment	Operated
Jeffrey City,			Drifts	Est (
Wyoming				

An Alpine Miner equipped with a Serpentix conveyor is driving mining headings in soft sandstone. Conventional drifts are also being driven in similar formations.

Mathe "B"	Cleveland Cliffs	10' x 10'	Various	Own Force
Mine	Iron Company Ishpeming,			
	Michigan			

Conventional timbered and untimbered development drifting on the 12th level in graywacke at 3,480' depth, conventional and Alpine Miner stope development in iron formation and ore above main levels.

APPENDIX B
RAW DATA SHEETS

	Identification		. I was a second of the secon	
***	**	Page Page	Identification	Page
	NAST-1	B-1, B-2	521	B-51, B-52
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	GA-1	B-9, B-10	72-1	B-57, B-58
	H-1	B-11, B-12	MSU-1	B-59, B-60
	H-2	B-13, B-14	MSU-2	B-61, B-63
	LK-1	B-15, B-16	LAW-2	B-63, B-64
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	LK-5	B-19, B-20	LAW-4	B-67, B-68
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, j.	□ CL-1	B-27, B-28	EVG-1	B-75, B-76
	LK-3	B-29, B-30	EVG-2	P-77, B-78
	LK-4	B-31, B-32	LAY-1	Б-79, В-80
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	CR-1	B-39, B-40	RO-1	B-87, B-88
	HS-1	B-41, B-42	WNG-1	B-89, B-90
	NY-1	B-43, B-44		B-91, B-92
	NY-2	B-45, B-46	WNG-2	B-93, B ,4
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	MB-2	B-49, B-50	SF-2	B-97, B-98
			KM-1	B-99, B-100

APPENDIX B

RAW DATA SHEETS

		,
0 0 0 0	SHOPE HON SCHMIDT	NA
Q Z	HOH	¥
	SHOPE	Y Y
Ron	PCT EST.	06
COMPR	STRNTH KPS1	<b>8</b>
DRY	PCF	167
HOCK PROPERTIES IGNEDUS: GRANITE, GRAY, MEDIUM	10 FINE GRAINEO, MODERATELY TO SLIGHTLY FRACTURED AND JOINTED 10 TO 20 PCT GUARTZ, SO TO AR	PCT FELUSPAH, SALANCE DARK MINERALS.
KEY IDENTIFICATION I NAST	SAMPLE NO	
KEY 1		

		PCT (-) ND200	28.5
:5		6IN. 31M. 21N. 1/21N. NO4 NO8 NO16 HO30 NO50 NO100 NO200 ND200	6.
SHOPE MON SCHHIDT	N A	NO100	14.9 12.5 12.4 12.3 8.6 11.8 6.8
HOH	ž	NOSO	9.
SHOPE	N.	0030	
Rab PCT EST.	8	SCREENS.	2.4 IZ
STRNTH KPS1	<b>E</b>	SETWEEN S	12.5
PCF	167	WEIGHT I	14.9
		CENT BY	2.2
ATELY TO	DARK	N. IIN.	0.0
TO FINE GRAINED, MODENATELY TO SLIGHTY FRACTURED AND JDINTED 10 TO 20 PCT OUARTS, SO TO A	BALANCE	31N. 211	0.0 0.0 0.0 2.2
E GRAINE LY FRACT	LUSPAR, LS.	* 61N.	•
TO FIN SLIGHT	PCT FE MINERA	PCT(+)6 IN-517E	0.0
		TA II MOISTURE P F PCT I	4
SAMPLE NO		IT MO	6
SAMP		MUCK DATA DRY UNIT WT PCF	83

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=RDUNDEO P=PLATY C=CUBIC I=IRREGULA? E=ELO

PI AI AI AI SI S  OL CHANGE  OLINITS  LIMITS   2						
PI AI AI AI AI AI AI AI AI AI AI AI AI AI	AN CACCOMONIES SPRING		TDUGHESS	0.16	SIZE(*)0.185 IN. ANGLE INTER FRICTION DEGREES AT 8.5 PCT HOIST	
PI AI AI AI AI AI AI AI AI AI AI AI AI AI		v			* NOIST	
PI AI AI AI AI AI AI AI AI AI AI AI AI AI		IS	FLOW	3.0	BU.K DENSITY PCF AT	
PI AI AI AI AI AI AI AI AI AI AI AI AI AI		7			IT IN HOIST	
PI AI AI AI AI AI AI AI AI AI AI AI AI AI		I	PLASTICITY INDEX PCT	0.50	APPAKEN COHES IO PSF AT	2
0 S S S S S S S S S S S S S S S S S S S		Ψ	•S12E(-		IST	
0 S S S S S S S S S S S S S S S S S S S		¥	IG LIMITS. SHRINKAGE IMIT	19.50	-) 0.50 NGLE/SL10 TEEL PLATI EGREES AT	3
0 S S S S S S S S S S S S S S S S S S S		ď	C S S S S S S S S S S S S S S S S S S S		AIAL SIZE ( SSE	
T VOL CHANGE LIQUID 10.005 IN.SIZE LIQUID 0.50IN.SIZE			PLASTI LIMIT PCT	14.00	ANGLE / HEPG ANGLE / HEPG 10 IN UROS DEGFES A1 9.0 PCT MG	36
T VOL CHANGE 10.065 IN.SIZE 0.50IN.SIZE ANGLE VITY I IN 0.50F			LIGUID LIMITS PCT	14.50	ZARPOSE OROP ES AT CCT MOIST	
7 VOL C. 0.501N.			IN.SIZE		SIZE ANGLE I IN OEGRE 9.0 F	37
9.5 SEE			POT VOL CH	0	(+) 0.50IN. SPECIF GRAVITY	5.69

TUNNEL		VENTI	VENTILATION			WATER INFLOW	UTILITY LINES	POWER SYSTEM	
SIZE SHAPE 9FT ROUND	GRADE +0.22PCT	10K	PRESS EXHST SI	S12E 221N	<u>+</u>	6PH 5-20	AIR MATER PUMP 6IN 2IN 6IN	PRIMARY SECONDARY 4160V 480V	<u>&gt;</u>
HAULAGE SYSTEM				SUPPORT	SUPPORT SYSTEM				
MUCK PAIL+ 361N GAGE- 70LB AAIL- 16 CY GASS	PERSONNEL RA1L		SUPPLY	BULT.TY 4-11N X GROUTER	buLT.TYPE SIZE 4-11N X 7FT GROUTEN	ROOF PLATE 131N X 10FT 16 GAGE	SET.SIZE.SHAPE 4IN RING AND HALF SETS 4FT, 3FT. AND 2FT IN BAD GROUND	SHOTCRETE	

1A TUNNEL DATA

KEY

THRUST. HAX/OPERATE	KL8 290
OPERATE	CENTER KFTL8
TORQUE. MAX/OPERATE	MEAD KFTLB 150 KFTLB 110
X d d	HEAD CENTER HEAD 8.5 INTEG KFTLE
ES	GAGE 6 MUGNES/WIRTH 1CB 11.5IN TCB MOLLER
UTTERS.MAKE.TYPE.UIAM.CUTTING EOGES	interior 15 Hughes/4[Hth TCB 11.5IN RULLER
CUTTERS.MAKE.TYP	CENTER 2 HUGHES/AIRTH 1CB 11.51N ROLLER 2-TCH 11.51N TCB CONE
	41 67 10NS
	MODEL HAROPOCK
МАСНІКЕ	MAKE MIRTH ERKEL: NZ

THKUST/SQ FT		KLB 3.89		
GUIDANCE	LASER			
POWER SYSTEM	HYDRAUL 1C.	POWERED BY	3-200HP MOTORS	
MUCK SYSTEM	BUCKET FROM	FACE, 221N	CONVEYOR TO	REAR
ANCHOR PRESS		KLB		

CONVENTIONAL EXCAVATION

MUCKING		
BLASTING		
EXPLOSIVES. POWDER FACTOR	IOIAL LHS PRIMERS. TRIM	INTERIOR CUT
ROUND. NO. HOLES	OLFIH COIA.	
MACHINE	MACAINES	FEED LENGTH

MACHINE EXCAVATION

SHORE MOH SCHMIDI	¥
HARONE MOH	¥Z
SHORE	N N
R00 PCT EST	06
COMPR STRNTH KPSI	18
PET	167
ROCK PROPERTIES IGNEDUS: GRANITE, GRAY, MEDIUM TO FINE GRAINED, MODEWATELY TO SCHOHLY FRACTURED AND JOINTED TO TO A DOT GRANITE	PCT FELUSPAR HALANCE DARK HENERALS.
IDENTIFICATION NAST SAMPLE NO NAST-2	
¥ o	

		PCT (-) N0200	8-01
		IN. 3IN. ZIN. IIN. I/ZIN. ND4 NO8 NDI6 ND30 NO50 NDI00 ND200 ND200	
SHORE MON SCHNIDI		00 I O	ις.
MOM NA		NOSO	7.7
SHORE		ND30	3 6.6
PCT EST 90		SCREENS.	1.5 IO.
STRNTH KPSI I8		BETWEEN S	3.8 II
PCF 167		WEIGHT	0.0 0.0 0.8 8.0 25.0 13.8 11.5 10.3 6.6 7.7 5.5
		CENT BY	8.0
ATELY TO JOINTE DARK		N. IIN	0.8
D. MODE URED ANI UARTZ SI ALANCE I		3IN. 21	0.0
TO FINE GRAINED, MODEMATELY TO SLIGHTLY FRACTURED AND JOINTED IO TO 20 PCT QUARTZ SO TO 60 PORT FELUSPAR HALANCE DARK	<u>.</u>		0
SLIGHT SLIGHT 10 TO PCT FE		PCT(+)6 IN.SIZE	0.0
0		ATA AIT MOISTURE P	10.8
SAMPLE NO NAST-2		250	9/
vi z		MUCK DRY L	7

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=KOUNDED P=PL

E.R.O					
L. JOHLEN JAILS REARGOLAN SESUBANGOLAN NEKOUNDEU PEPLATY CECUBIC IEIRREGULAR EEELONGATEO SPESFMERO		,		IN.	
EO Si				NTER NAT	
NGAT		SS		SIZE(+)1.0 I ANGLE INTER FRICTION DEGREES AT 8.5 PCT MOIST	31
=ELO		TOUGHNESS	0.28	SIZE FRI PRI 8.5	
AR.		TOUGHA	٥	-	
EGUL L	v			IITY AT PCT MOIST	
# I # I				ATT TO TO	ž
316	Is	FLOW	9.4	BULK DENSITY PCF AT PCT	
				TST	
AT A	SI			RENT SION AT PCT MOIST	<b>4</b>
7 7	н	**************************************		APPARENT COMESION PSF AT PCT M	-
DEC	•	PLASTI	, m	4 0 8	
	I.V	(•)	1.3		
¥ .		215*		E E IST	
	PI	ERG LIMITS. SHRINKAGE LIMIT		E(-) 1.0 IN ANGLE/SLIDE STEEL PLATE OEGREES AT 8.7 PCT HOIST	6
200		MARINE T	17.9	GREE GREE	
n n	I	. # 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	_	17E (- An ST ST 0E 0E	
	I d	ATTE		ANGLE/REPOSE ANGLE/SL IO IN URDP STEEL PL B.7 PCI MOIST 8.7 PCT	
	Q.	211	N	ANGLE/MEPOSE 10 IN URDP DEGREES AT 8.7 PCI MDIST	
3		PLASTIC LIMIT PCT	18.2	PCT PCT	38
				ANG DEG	
•	11.1	LIGUID LIMITS PCI	S•6I	ANGE CREPOSE IN ORDA DEGREES AT B.7 PCT MOIST	
		•.228	16	PREPOP T A T	
		ш		IN D GREE	38
		6E • SIZ(		+ <b>₹</b> ⊢ <b>G</b> ®	
		CHAN		S	
,		. 656		F ITY	so.
		POT VOL CHANGE (-)0.056 IN.SIZE	•	SPECIF GRAVITY	2.66

	STEM	SECONDARY 480V				THRUST . MAX/OPE	KLB 290			GUIDANCE
	POWER SYSTEM	PRIMARY 4160V		SHOTCRETE		OPERATE	CENTER KFTL8 KFTL8			MUCKING
	UTILITY LINES	6IN 2IN 6IN		SEI.SIZE.SHAPE 4IN RING AND HALF SEIS 4FI. 3FI. AND 2FI IN BAD GROUND APPROX. 650FI		RPM TORQUE, MAX/OPERATE	HEAD.CENTER HEAD 8.5 INTEG KFTLB 150 KFTLB 110			BLASTING
	WATER INFLOW	6P± 5-20		MOOF PLATE ISIN X IOFT IS GAGE		ies	GAGE 6 HUGHES/WIRTH ICB II.5IN TCB MOLLER	THRUST/SQ FT KLM 3.89		. 80
		S12E +5	SUPPORT SYSTEM	doll.TYPE SIZE 4.IIN X 7FI GROUTED APPROX.		.UIAM.CUTTING EDG	INTERIOR IS HUGHES/WIRTH. TCB II.SIN RULLER	GUIDANCE THRUS LASER KLH 3		EXPLOSIVES, POWOER FACTOR TOTAL LBS TOTAL LBS THIN INTERIUR CUT
	VENTILATION	CFM PHESS EXHST		SUPPLY		CUTTERS, MAKE, TYPE, UIAM, CUTTING EDGES	CENTER 2 HUGHES/WINTH 1CB 11.51N POLLEH, 2-1CB 11.51N CONE	POWER SYSTEM HYDRAULIC+ POWERED BY 3-200HP MUTORS		40. FH FH FH
		GRAJE +0.22PCT		PERSONNEL RAIL	NO		# 1 6 7 TONS	MUCK SYSTEM BUCKETS FROM FACE, 22IN CONVEYOR TO REAR	AVATION	ROUND. NO. HOI DEPTH OIAM. CUT,
2A TUNNEL DATA	TUNNET.	SIZF SHAPE 9FT ROUND 9 IN	MAULAGE SYSTEM	MUJCK RAIL, 36IN GAGE 70LR RAIL, 16 CY CARS MOTOR IZ TON	MACHINE EXCAVATION	MACHINE	MAKE MODEL AIRTH HAROROCK ERKELENZ	ANCHOR PRESS MI	CONVENTIONAL EXCAVATION	MACHINES HACHINES FEED LENGTH

THRUST.MAX/OPERATE

KLB 290

KEY

:5	
SCHMI	X X
Pones	_
HA	ž
SHORE MDH SCHMIDT	¥
Roo PCT EST	96
COMPR STRNTH KOSI	6
02.5	H
DRY #T PCF	152
ROCK PROPERTIES IGNEOUS: BIOTITIC GRANITE FINE GRAINED: MAJOR QUARTZ, MINOM FELOSPAM AND DARK MINERAL CONTENT.	
SAMPLE NO NAST -3 NAST	
X	

		PCT (-) NO200	3.8
		ND200	
SCHMIDT	A A	001QN	1.5
MOM	¥ z	ND50	2.8
PCT SHORE EST	¥.	ND 30	2.6
	96	SCREENS.	.3 6.I
STRN IH	<b>E</b>	BETWEEN S	8.
PCF	152	WEIGHT ND4	۶. 6.5
		CENT BY	13.7
ERAL		IN. IIN	12.6
FELOSPAR AND DARK MINERAL CONTENT.		6IN. 3IN. 2IN. IIN. 1/2IN. ND4 NO8 ND16 ND30 ND50 ND100 ND200 ND200	16.2 6.2 12.6 13.7 6.9 5.8 5.3 6.1 2.6 2.8
DSPAR AL			
E S		PCT(+)6 IN-SIZE	14.5
0		ATA NIT MDISTURE F CF PCT 1	3.4
SAMPLE NO		MUCK DATA DRY UNIT	111

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHERDID

207				
			R IN.	
	TDUGHNESS INDEX	I5*0	SIZE (-)2.0 IN ANGLE INTER FRICTION DEGREES AT 3.0 PCT MDIST	9
₹,			• MD1ST	0
I	FLOW	4.10	APPARENT BULK CDHESIGN DENSITY PSF AT PCF AT 3.0 PCT MDIST 0.0 PCT MDIST	6.10
IV	Z <b>-</b>		ION THE TOTAL	08
AI	PLASTICI INDEX PCT	2.63	APPANENT COMESION PSF AT 3.0 PCT	
AI	.S12E (•	N	ST ST	
AI A'I	PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT PLASTICITY PCT PCT PCT PCT PCT PCT PCT PCT PCT PCT	17.13	ANGLE/KEPOSE ANGLE/SLIDE ANGLE/KEPOSE ANGLE/SLIDE OF STEEL PLATE DEGREES AT DEGREES AT 2.8 PCT MOIST	31
AI	STIC ATTER	17.41	ANGLEKREDSE ANGLEKREDSE ID IN DROP DEGREES AT 2.8 PCT MDIST	
AI AI	7 12	17	ANGLE/ 10 IN DEGREE 2.8 PC	36
	LIQUID LIMITS PCT	19.50		
AI		ı	ANGLE/REPO IN DROP DEGREES A'	36
	CHANGE IN.SI		N.SIZE	
	POT VOL CHANGE (-)0.056 IN.SIZE	0	(-) 0.7SIN.SIZE ************************************	2.65

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w	

34 TUNNEL DATA

POWER SYSTEM	PRIMARY SECONDARY		SHOTCRETE
UTILITY LINES	ATH SATES FORE ADS 215 ACS		SET.SIZE.SHAPE NA
WATER INFLOW	6₽# 5-10		ROOF PLATE 131N X 19FT 16 GAGE
	SIZE HP 22IN	SUPPORT SYSTEM	BOLT-17PE SIZE 11 IN A 7FT GROUTED
NTILATION	H PRESS EXHST		SUPPLY
VE	GRADE CFM 0.0 IOK		PERSONNEL Rail
TUNNEL	SIZE SHAPE 10FT X ALCOVE 16FT X8FT	HAULAGE SYSTEM	MUCK RAIL 35IN GAGE. 70LB RAIL. 16 CY CARS 4010R 12 TON

# MACHINE EXCAVATION

THRUST . WAX/OPERATE		FL8
RQUE . HAX/OPERATE	CENTER	KFTLB
TOROUE.	HEAD	KFTLB KFTLB
RPM	HEAD CENTER HEAD	
ING EDGES	GAGE	
MAKE.TYPE.UIAM.CUTTING EDGES	INTERIOR	
CUTTERS.HA	CENTER	
	**	
	HODEL	
MACHINE	HAKE	

THKUST/SO FT	KL8
GUIOANCE	
POWER SYSTEM	
HUCK SYSTEM	
ANCHOR PRESS	KLB

KLB

# CONVENTIONAL EXCAVATION

BLASTING ELECTRICAL 0-7 REGULAR	DELAYS	
EXPLOSIVES, POVOEM :ACTOR 6.3LB/CY TOTAL LB: 300 GELEX 2, 60PCT	PRIMERS. INTERIOR CUT	LITERS
ROUNO. NO. HOLES 72 DEPTH 9FT	CUT. COUBLE V	
MACHINE ROUND. JUMBO NO. HOLES 72 MACHINES JACK LEG 2-553F DEPTH 9FT	FEED LENGTH 4FT	

GUIDANCE

SHORE HOH SCHKIDT	AN.
• HARDI MOH	¥ Z
SHORE	A N
ROD PCT EST	06
COMPR STRNTH KPSI	<b>\$</b> 2
PET	160
ROCK PROPERTIES IGNEOUS, GRANITE, FINE GRAINED MOGRAFIELY FMACTUMED, MAJOR QUARTZ AND MINOR FELDSPAR CCNTENTS.	
ROPERIES S. GRANITE TELY FHACI AND MINOR	
COCK FIGNEOU COERA	
~ ~ 5 O O	
IOENTIFICATION NAST SAMPLE NO NAST-4	

KEY 4

PCT (-)	5.9
6IN. 3IN. ZIN. 11N. 1/ZIN. NO4 NO8 NO15 NO30 NO50 NO100 NO200 N	8.
NOSO NG	;
N030	0 14.5
SCREENS	2.7 11.
F BETWEEN NOS	0.0 0.0 0.0 11.5 20.6 13.6 12.7 11.0 14.5 4.4
BY WEIGH'	20.6
PER CENT	11.5
N. ZIN.	0.0
6IN. 3II	0.0
PCT(+)6 IN-S12E	0.0
HOISTURE PCT	17.2
MUCK DATA DAY UNIT	83

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID

AI

V

PI

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TOUGHNESS	90.0	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 7.1 PCT HOIST	· ·
FLOW TOUGHNESS INDEX	3.40	BULK BULK DENSITY PCF AT 0.0 PCT MOIST	e. O
	0.23	APPARENT COHESION PSF AT 7-I PCT MOIST	o
PLASIC SMRINKAGE PLASICITY LIMIT LIMIT PCT PCT	17.50	ANGLE/HEPOSE ANGLE/SLIDE ANGLE/HEPOSE ANGLE/SLIDE 10 IN UPOP STEEL PLATE DEGMEES AT DEGREES AT 6.9 PCT HOIST 6.9 PCT MOIST	07
PLASTIC LIMIT PCT		:	34
SIZE LIQUIO	14.20	(-) 0.7SIN.SIZE ************************************	39
PDT VOL CHANGE (-)0.056 IN.SIZE	0	(-) 0.7SIN.SIZ! SPECIF GPAVITY	2.64

	DATA
KEY	4A TUNNEL

POWER SYSTEM	PRIMARY SECONDARY		SHOTCRETE *
UTILITY LIMES	AIR WATER PUMP 6IN 2IN 6IN	100	SET.SIZE.SHAPE 4IN RING AND HALF SETS. 4FT. 3FT. AND ZFT IN BAD GROUND APPROX. 6SOFT
WATER INFLOW	нь бри 520	UPPORT SYSTEM	BOLT-TYPE SIZE ROOF PLATE 4-IIN X 7FT 13IN X 10FT GROUTED 16 GAGE APPROX. I200FT
	PRESS EXHST SIZE X ZZIN	SUPPORT	bOLT.TYPE SIZE 4-IIN X 7FT GROUTED APPROX. IZOOFT
TILATION			SUPPLY
VENT	6RADE CFM +0.22PCT 10K		PERSONNEL RAIL
	SHAPE	MULAGE SYSTEM	6 CY 6 CY 2 TONS
TUNNEL	S12E 9FT 10TN	MAULAGE	MUCK RAIL, 36IN GAGE, 70L3 RAIL, 16 CY CARS MOTOR 12 TONS

## MACHINE EXCAVATION

MACHINF			CUTTERS, MAKE, TY	SOMMETTYPE, DIAMOCUTTING EDGES	<b>E</b> DGÉS	A PR	TORQUE. HAX/OPERATE	/OPERATE	THRUST - MAX / CPSRATE
	HOOEL HAZDROCK	1 M 6 7	CENTER 2 HUGHES TCH	INTERIOR ICE	GAGE TOB	HEAD+CENTER HEAD	HE 40	CENTER	
ERKELENZ MUGHES MEAD		TONS	11.51N ROLLER. 2-11.51N CONE	II.SIN ROLLER	11.51N ROLLER		KFILD 150 KFILB	KF1L8	KLB . KLR 630
ANCHOR PRESS MUCK SYSTEM	MUCK S	rSTEM	POWER SYSTEM	GUIDANCE THRISTICS ET	SISTAGO ET		#r	4	**************************************

GUIDANCE THRUST/SQ FT LASER KLB 8.45

POWER SYSTEM HYDR...LIC POWERED HY 3-230HP MOTORS

MUCK SYSTEM BUCKET FACH FACE, 22FT CONVEYOR TO REAR

KL9

# CONVENTIONAL EXCAVATION

EXPLUSIVES, POWDER FACTOR TOTAL LBS PPINERS,	IRIM INTERIOR CUT LIFTERS
ROUND. NJ. HOLES DEPTH OIAM.	•
MACHINE JUMBO MACHINES	FEEO LENGTH

GUIDANCE

MUCKING.

BLASTING

	SHORE MOH SCHMIDT	4	
ESS	Ö,	_	
MRDN	E O	AN.	
	2	Z	
	HORE	¥	
ROC	EST	96	
	I		
OMPR	KPSI	.Z	
	, T	.,	
ž.	PCF	191	
0		16	
.*.	•		
ROCK PROPERTIES IGNFOUS: GRANITE, MASSIVE,	ONTEN		
A N	A CC		
IES NITE	INEK.		
PERT GRA	K (K		
PRO	A O S		
ROCE	NIN		
NO L			
FICA E AD	NO NO		
OENTIFICATION	SAMPLE NO		
-0	SA		
KEY S			

		7	
		PCT (-NO200	3.5
		**************************************	2.0
	AN AN	OION	3.6 0.2
	AN A	90N	3.7
3	96 NA	EENS	5.6
		FWEEN SCRI	5.6
	35	FEIGHT BE	9.9 4.0
	191	CENT BY .	11.7
		IN. IIN	10.3
			17.9 12.2 10.3 11.7 14.4 6.6 5.6 5.6 3.7 3.6
		* *	F. 4
		MOISTURE PCT(+)6 PCT IN.SIZE	1.9
GA-1		MUCK DATA DRÝ UNIT WI PCF	114

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATEO SP=SPHERGID

N HERG	- 8:		ž.
AI AI AI AI AI AI AI	TOUGHNESS	0.14	SIZE(-)?.0 ANGLE INTER FRICTION OEGREES AT 0.9 PCT HOIS
AI AI			HUIST
AI	FLOW	3.00	BULK BENSITY PCF AT 0.0 PCT MUIST
I V	NT.		APPARENT COHESION PSF AT 0.9 PCT MOIST (
AF	0.056 LASTIC	0.42	APPA COHE PSF
. 14	12E(÷)	0	IN.
41	PLASTIC SHRINKAGE PLASTICITY LIMIT PLASTIC PLASTICITY LIMIT PCT PCT	13.67	LATE ATE
¥I	TERBER S L		S
AI AI	PLASTIC LIMIT PET	15.78	ANGLE/MATERIAL SIZE(-)2.0 ANGLE/MEPOSE ANGLE/S IO IN UROP SIEEL P DEGREES AT DEGREES 0.9 PCI MOIST 0.9 PCI 36
Į <b>V</b>			°
	LIOUID LIMITS PCT	16.2	REPORZ ROP S AT T HOIST
I	POT VOL CHANGE (-)0.056 IN.SIZE		(-)0.75 IN.SIZE ************************************
	POT VOL	0	(-)0.75 I SPECIF GRAVITY 2.59

SA TUNNEL DATA

KEY

POWER SYSTEM	PRIMARY SECONDARY		SHOTCRETE
UTILITY LINES	AIR WATER PUMP 6IN 2IN		SET.SIZE.SHAPE 4IN WE SIEEL, SETS AT 4FIT, APPROX.
WATER INFLOW			ROOF PLATE
	<u>a</u>	SUPPORT SYSTEM	HOLT TYPE SIZE ROOF PLATE AIN X 7FT GROUTEO APPROX 35FT
PENTILATION	CFM PRESS EXHST SIZE AK X 22IN		SUPPLY EINCO 912 LND DIESEL
>	SHAPE GRADE C HORSESHDE -0.22PCT A	STEM	LMD NONE
TUNNEL	SIZE SIDET X HI	HAULAGE SYSTEM	HUCK EIMCO 912 LMD DIESEL

MACHINE EXCAVATION

THRUST. HAX/OPERATE		. 8 8 7 Y
TORQUE . HAX/OPERATE	CENTER	KFTL8
TORQUE .	HEAD	KFTL8 KFTL8
X d a	HEAD CENTER HEAD	
iĠ EOGES	GAGE	
MAKE.TYPE.DIAM.CUTTING EGGES	INTERIOR	
CUTTERS. MAKE	CENTER	
	7	,
	400EL	
MACHINE	MAKE	

GUIDANIE THHUSTASS

POWER SYSTEM

ANCHOR PRESS MUCK SYSTEM

KLB

CONVENTIONAL EXCAVATION

 70PCT		
6.1LB/CY GELEX 2.		
EXPLOSIVES. FOLB/CY. POWDER FACTOR 6.1LB/CY. TOPCT DDIAL LBS ITS GELEX 2. 70PCT DDIMED.	TRIM	CUI
ROUND. NO. HOLES 18 DEPTH 8FT OIAM. 1-3/41N	CU1. DOU	SF/HDLE 2.I
MACHINE JUMBO CFAWLER MACHINES 2-093 DRIFTER	FEED LENGTH 10FT	

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		PCT (-)	3.4	3×SPHEROID	9			. IN 18	
SS SCHMIOT	¥ Z	NO100 NO200	2.2	LAR E*ELONGATED SI	Ì	TOUGHNESS. INDEX	0.23	SIZE(-)2.0 I ANGLE INTER FRICTION DEGREES AT 1 2.2 PCT MOIST	\$
SHORE HOH SCHMIDT	NA NA	NO30 NOS0	3.0 3.8	UBIC I≈IRREGU	AI AI	FLOW	•	BULK BULK DENSITY PCF AI	Ą
ROD ROD	80	SCREENS	4.3 4.1	40EO PEPLATY CEC	AI AI	PLASTICITY		APPARENT COMESION PSF AT PCT MOIST	¥
ORY COMPR WI STRNIH PCF KPSI	163 32	PER CENT HY WEIGHT BETWEEN N. IIN. 1/2IN. NO4 NO8	12,9 5,7	A=ANGULAR S#SUBANGULAR R=ROUNDEO PEPLATY C#CUBIC I=IRREGULAR E#ELONGATED SP*SPHEROID	ĀĪ AI	PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT INDEX ICT PCT POL	•	SIZE(-)2.0 IN AMGLE/SLIDE STECL PLATE DEGREES AT 1.3 PCT MOIST	32
PERTIES GRAVITE, GRAY, FINE HOBERATELY JOINTEO, TO 2 FT BANDS OF N PEGMATTIF AND	GRANITIC GNEISS.	3IN. ZI	6.6 12.7 13.2 13.6	CREEN SIZES A=ANGULAR S	AI AI AI AI	PLASTIC S LIMIT L PCT	17.0	ANGLE/MEPOSE AN 10' IN UROP ST 0EWHEES AT DE 1.3 PC! MOIST 1.3	37
ROCK PROP IGNEOUS: GRAINED: WITH 1.5		PCT(+)6 *	14.3	SHAPE OF FRACTIONS BETWEEN SCR	AI	IN-SIZE LIMITS PCT	18.0	ANGLE/REPOSE IN OROP OEGREES AT	0
KEY IDENTIFICATION 6 HUNTER SAMPLE NO H-1		MUCK OATA ORV UNIT MOISTURE WT PCF PCT	107 3.4	SHAPE OF FRAC		POT VOL CHANGE (-)0.056 IN.S	0	(~)0.75 IN.SIZE SPECIF GRAVITY	2.70

		DATA
-	<b>6A</b>	TIMME

POWER SYSTEM	PRIMARY SECONDARY 4160V 440V		SHOTCRETE SOOPSI 18 HRS 3750PSI 28 DAYS 16 PCT OF 7200
UTILITY LINES	AIR MATER PUMP BIN 4IN IOIN		SET.SIZE.SHAPE 4IN WF SETS. 4FT. 3FT. 2FT FOR 23PCT
WATER INFLOW	GPH 20-400		ROOF PLATE
No	PRESS EXHST SIZE HP  A 26IN 125	SUPPORT SYSTEM	SUPPLY BOLT, TYPE SIZE RAIL IIN X 7FT GROUTEO I7PCT
VENTILATION	SHAPE GRADE CFM PRE HORSESHOE +0.25PCT ISK HODIFIED		PERSONNEL RAIL
TUNNEL	SIZE SHAPI IOFI X HORSI IOFI HODI	HAULAGE SYSTEM	MUCK RAIL, 36IN GAGE 75LE RAIL, 4.8 CY CARS, 15TON LOCCHOTIVE

# MACHINE EXCAVATION

THRUST, MAX/OPERATE		818 X X X
TORQUE .MAX/OPEHATE	CENTER	KFTL8 KFT, B
TORQUE	HEAD	KF1L8 KF1L8
ВРМ	HEAD.CENTER HEAD	
	GAGE	
ING EDGES	3	
UTTERS.MAKE.TYPE.UIAM.CUTTING EDGES	INTERIOR	
HAKE . TYP		
CUTTERS	MT CENTER	
	38	
	MODEL	
HACHINE	MAKE . MODEL	

THRUST/SO FT	KLB
GUIDANCE	
POWER SYSTES	
WUCK SYSTEM	
ANCHOW PRESS	KLB

# CONVENTIONAL EXCAVATION

EXPLUSZVES: POWDER FACTOR 5.5LB/CY TOTAL LBS 200 PRIMERS: GELEX 2-1 1/2 IN TRIM 20LG SMOOTHTEX 70PCT X 7/8IN INTERIOR GELEX 2-1 1/2 IN LIFTERS GELEX 2-1 1/2 IN-	
ROUND. NO. HOLES 38 DEPTH IO.SFT OIAM. 1-3/4/N CUI. SPIRAL BURN SIN CENTER HOLE	
MACHINE JUMBO 4 BOOM HYDROJIB MACHINES 4-CF99 1-CF133 FEED LENGTH 12FT	

SHORE HOH SCHHIDT	AN.
MOH	¥.
SHORE	*
PCT EST	90
COMPR STRNTH KPSI	39
PET	16
ROCK PROPERTIES IGNEOUS: GRANITE GRAY, GNEISSIC, MODERATELY JOINTED.	
IDENTIFICATION HUNTER SAMPLE NO H-3	
X V	

	1	PCT (-)	3.3
		NO200	
SHORE MOH SCHMIDT	<b>4</b> 2	00 I O0	II.7 18.2 19.3 II.6 9.3 4.8 4.2 4.5 3.4 I.3 I.I
HARONE MOH	¥	NOSO	1.3
	<b>4</b>	N030	3.4
PCT EST	80	CREENS	2 4.5
STRNTH	ê î	BETVEEN S	.8
# 6 € - 5	164	Y WEIGHT	4.3
•		R CENT 8	11.6
Y JOINTEO		ZIN. III	.2 19.3
C. MODERATELY JOINTED.		6IN. 3IN. 2IN. IIN. 1/2IN. NOA NOB NOIG NO30 NOSO NOIDO NO200 NO200	11.7 18
GNEISSIC		PCT(*)6 IN.SIZE	7.3
QN.		MOISTURE PCT	3.4
SAMPLE NO		HUCK DATA DAY UNIT	601

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=KOUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID

2					
THE COCCUPATION OF THE COCCUPATI		TOUGHNESS INDEX	40.0	SIZE(-)2.00 IN. ANGLE INTER FRICTION DEGREES AT 2.6 PCT HOIST	
9	4			• •	
		_ ×		LK NSITY F AT P	105
	IA.	FLOW	3.20	3000	
	A1			APPARENT COHESION PSF AT 2.6 PCT MOIST	3
		* ×		SION PCT	90
	AI	0.056 PLASTIC INDEX PCT	0.15	APPA COHE PSF	
	¥.	2É (-	•		
		••\$1		IN	
	¥1	PLASTIC SHRINNAGE PLASTICITY LIMIT PCT PCT PCT PCT PCT PCT PCT PCT PCT PC	11.00	ZE(-)2.0 IN. ANGLE/SIDE STEEL PLATE DEGREES AT 3.8 PCT MOIST	86
	AI	ERBERG SH	-	SIZE(= ANG ST 3.8	
	¥	TIV	•	ST ST	
		110	98	ROP ROP AT	
	٧I	P. P. P. P. P. P. P. P. P. P. P. P. P. P	17.95	ANGLE MEDOSE ANGLE/S ANGLE/MEDOSE ANGLE/S 10 IN UROP STEEL P DEGREES AT DEGREES 3.8 PCT MOIST 3.8 PCT	38
	AI			4.00	
		LIANTS PCT	01.10	)SE     IST	
		LIB	18	19.59	
	A1	w		(-) 0.75 IN.SIZE ************************************	36
		GE SIZ		2 E S S S S S S S S S S S S S S S S S S	
		CHAN		N.SI	
		VOL . 056		IF ITY	
		POT VOL CHANGE (-)0.056 IN.SIZE	0	PP 0	2.60
				3 4.0	N

CURRENT! I SEPT. 1972

¥-2

KEY 7A TUNNEL DATA

CTEM	PRIMARY SECONDARY 4160V 480V		
POWED CITEM	PRIMARY 4160V		SHOTCRETE
UFILITY LINES	AIR WATER PUMP BIN 4IN 10IN		SET.SIZE.SHAPE
WATER INFLOW	GPM 20-400		ROOF PLATE
	HST SIZE HP X 26IN 150	SUPPORT SYSTEM	HOLT.TYPE SIZE R MINOR HOCK HOLT JIN X 7FT GROUTEO
/ENTILATION	H PRESS EXHST		SUPPLY RAIL
VĒ	SHAPE GRADE CFM HORSESHOE +0.25Ps/ BK MODIFIED		PERSONNEL MAIL
TUNNEL	SIZE SHAPE 10FT HORSESH 10FT HODIFIE	MAULAGE SYSTEM	MUCK RAIL. 35IN GAGE 75LB RAIL. 4.9 CY CARS. 15TON LOCOMOTIVE

MACHINE EXCAVATION

THRUST . MAX/ODFRATE		KL8 KL8
ORQUE.MAX/OPERATE	CENTER	KFTL8
TORQUE.	HEAO	KFTLB KFTL8
КРи	HEAD, CENTER HEAD	
4G EUGES	GAGE	
AKE.TYPE.UIAM.CUTTING EUGËS	INTERIOR	
CUTTÊRS.MAKE	CENTER	
	*	
	MODEL	
MACHINE	MAKE	

ANCHOR PRESS MUCK SYSTEM POWER SYSTEM GUIDANCE THRUST/SQ FT KLB

CONVENTIONAL EXCAVATION

BLASTING ELECTRICAL 0-10 REGULAR DELAYS
EXPLOSIVES, POWDER FACTOR S.6LB/CY TOTAL LBS 225 PRIMERS, GELEX 2 TRIM 25L9 30PCT OUPONT 7/8IN x 24IN INTERIOR GELEX 2 CUT GELEX 2 LIFTERS GELEX 2
ROUND. NO. HOLES 36-40 DEPTH IJFT DIAM. 1-3/4IN CUT. SPIRAL BURN SIN CENTER HOLE
MACHINE JUMBO 4 BOOM HYDROJIB MACHINES 4-CF99 1-CF133 FEEO LENGTH 12FT

GUIDANCE

MUCKING EIMCO NO25 RAIL, AIR OPERATEO

SHORE MOH SCHMIDT	A N
HARDN	ž
SHORE	A N
ROD PCT EST	83
COMPR STRNTH KPSI	S2
ORY PCF	162
GOCK PROPERTIES IGNEOUS, BIOTITIC GUANTZ MONYONITE, FINE TO MEDIUM GRAINED PORPHYRY.	
LENITORION SAMPLE NO LK-1	

	6IN. 3IN. 21N. IIN. I/2IN. NO4 NO8 NOIG NOSO NOIGO NO200 NO200	4
	N0200	•
4 X	00101	0
<b>Y</b>	9507	0
<b>4</b> 2	9607	13.8 5.9 5.0 3.8 2.0 0.7 0.5 0.4 0.3 0.3 0.1
83 NA	REENS	4.0
v	WEEN SCI	0.5
	6HT BET	0.7
162	BY WEI	2.0
	ER CENT	3.8
	ZIN. I	8.0
	JIN	.8 5.9
	• • • • • • • • • • • • • • • • • • •	13
	PCT(+)6 IN-SIZE	66.8
	MOISTURE PCT	4.0
	MUCK DATA DRY UNIT	102

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHERDID

AI AI

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TDUGHNESS INDEA	0.30	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 0.4 PCT HOIST	5
FLOW	3.90	APPARENT BULK COHESION DENSITY PSF AT PCF AT 0.4 PCT HOIST 0.0 PCT HDIST	97.3
IE(-) 0.056IN PLASTIGITY INDEX PCT	0.12		438
ASIC SHRINKAGE PLASTICITY  ANI LIMIT PCT	17.69	ANGLE MATERIAL SIZE (-)2.0 IN ANGLE MEPOSE ANGLE SLIDE 10 IN UROP STEL PLATE DEUMEES AT DEGREES AT 0.8 PCT MOIST	53
PLASTIC LIMIT PCT	17.98	ANGLE/MEDOSE  IO IN UROP  DECMEES AT  0.8 PCT MGIST	30
ZE LIGUID PCT	18.10	ANGLEZREPOSE I IN DROP DEGREES A1	33
POT VOL CHANGE (-) 0.056 IN.SIZE	0	SPECIF ANGLE/REPOSE SPECIF ANGLE/REPOSE IN DROP DEGREES AT 0.8 PCT MOIS	2.85

LK-I CURRENTS . I SEPT. 1972

LK-1

BA TUNNEL DATA

	SECONDARY 220V		
Briad's ave	PRINGE 4160V		SHOTCRETE
UTILITY LINES	AIR WATER PUMP 6IN ZIN		SET.SIZE.SHAPE
WATER INFLOW	GPM .		ROOF PLATE 13.5IN X 9FT
	EXHST SIZE HP SURF 48IN ISO	SUPPORT SYSTEM	BOLT.TYPE SIZE 3/4IN X 6FI.
VENTILATION	CFM PRESS E		SUPPLY DIESEL TRUCK
	GRADE +5.5PCT		PERSONNEL OIESEL TRUCK
TUNNEL	SIZE SHAPE ISFT X ARCHEO 16FT BACK	HAULAGE SYSTEM	WAGNER ST-8 SCOOPTRAM.

MACHINE EXCAVATION

ATE		
THRUST. MAX/OPERATE	. K. B.	
TORQUE.MAX/OPERATE HEAD CENTER	KF1L8 KF1L8	
TORQUE.	KFTL8 KFTL8	
RPH TORGL HEAO.CENTER HEAO		
NG EDGES GAGE		GUIOANCE THRUST/SQ FT
E.TYPE.UIAM.CUTTING EDGES INTERIOR GAG		GUIDANCE
CUTTERS.MAKE.TYPE CENTER		POWER SYSTEM
<u> </u>		SYSTEM
HOOEL		ANCHOR PRESS MUCK SYSTEM KLB
MACHINE		ANCHOR PRE

CONVENTIONAL EXCAVATION

NUCKING SCOOPTRAN
BLASTING ELECTRICAL 0-15 REGULAR DELAYS
EXPLUSIVES. PUNDER FACTOR 4.0 LB/CY TOTAL LBS 365 PRIMES. 25LB 1.5IN X BIN. 60-75PCT TRIM 25LH 7/BIN X 16IN. 30PCT INTERIOR ANFO CUT 40LB 1.5IN X 16IN. 45PCT
ROUND. NO. MOLES 47 NO. MOLES 47 NO. MOLES 47 OIAW. I-3/4IN FTER CUT. 6 MOLE BURN I-4IN CNTR HOLE SF/HOLE 5.4
MACHINE JUMBC 3 BOOM WACMINES GAMONER DENVER I-PRIZ3 Z-DMIZ3 DRIFTEF

			PCT (-)	I.3	P=SPHER010	ę			IN.	
СНИІОТ	4 2	1	NO100 NO200	0°5	A=ANGULAR S=SUBANGULAR R=ROUNOEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID		TOUGHNESS INDEX	0.058	SIZE(-)2.0 I ANGLE INTER FRICTION OEGREES AT	36
SHORE MOH SCHMIOT	¥ Z		NO50	1.0 0.8	IC I=IRREGULA	AI AI		2.9	BULK OENSITY PCF AT 0-0 PCT HOIST	97.6
ROD SHOREST.	83 HA		REENS	1.3	P=PLATY C=CUB	A	S6IN		ARENI ESION AT PCT MOIST (	210
COMPR STRNIH KPSI	82		EIGHT BETWEEN SCREENS.	2.0 1.8	AR R=ROUNDED	AI AI	PLASTIC SHRINGE PLASTICITY FLOW LIMIT LIMIT PLT POT PLASTICITY FLOW FOR INDEX	0.36	× +	
ORY PCF	165		ENT EY WI	5.5 5.3	AR S=SUBANGUL	AI AI	ERREG LIMITS SHMINKAGE LIMIT PCT	17.29	SIZE(-)2.0 ANGLE/SLIDE STEL PLATE DEGREES AT 6.7 PCT 4019	33
HOCK PROPERTIES IGNEOUS: BIOTITIC GUARTZ MONZONITE, FINE TO MELIUM GRAINED POMPHYRY, WILK MINOR STEEPLY INCLINEO JOINES.			JIN	16.9 8.7 5.8	SCREEY SIZES A=ANGUL	AI AI	PLASTIC LIMIT PCT	19.14	ANGLE/REPOSE 10. 10. NOP OEGREES AT 4.7 PCT MOIST	24
HOCK PROPERTIES IGNEOUS: BIOTIT HONZONITE, FINE GRAINED POMPHYR STEEFLY INCLINE			PCT(+)6 *	1.67		AI AI	LIGUIO LIMITS PCT	50.50	ANGLEZREPOSE 1 IN DROP OEGREES AT	ç
IDENTIFICATION LK SAMPLE NO LK-2			MOISTURE	I • 6	SHAPE OF FRACTIONS BETWEEN		POT VOL CHANGE (-) 0.054 IN.SIZE		IN.SIZE	4
SAMPLE LK-2			MUCK DATA	103	SHAPE		POT VOL (-)	•	SPECIF SPECIF GRAVITY	2.13

LK-2

KEY 94 TUNNEL OATA

	POWER SYSTEM PRIMARY SECONDARY 4160V 2260V		
	POWER SYSTEM PRIMARY SECO		SHOTCRETE
1171 TV 1 PARE	AIR WATER PUMP		SET+SIZE+SHAPE
WATER INFLOW	GPW NONE		ROOF PLATE 13.5IN X 9FT
	#P ISO	SUPPORT SYSTEM	dOLT.TYPE SIZE 3/4IN X 6FT AT 4FT
	SIZE 48IN	SUPPORT	3/41N X AT 4FT
ILATION	PRESS EXHST HEAD SURF		SUPPLY DIESEL · TRUCK
VENT	CFH 22K		
	GRADE +2.0PCT		PERSONNEL OIESEL TRUCK
	SHAPE ARCHEO BACK	SYSTEW	1-8 • 4
TUNNEL	SIZE 18FT X 16FT	HAULAGE SYSTEM	MUCK WAGNER ST-8 SCOOPTRAN- RAIL SKIP

MACHINE EXCAVATION

THRUST . MAX/OPERATE	KL8 KL8	
TORQUE, MAX/OPERATE HEAD CENTER	KFTLB KFTL8	
TORQUE.N HEAD	KFTL4 KFTL8	
RPM TORBY		
ų		GUIDANCE THṛUST/SQ FT KLB
E.UIAM.CUTTI INTERIOR		GUIDANCE
CUTTERS.MAKE.TYPE.UIAM.CUTTING EDGES CENTER INTERIOR GAG		POWER SYSTEM
**		K SYSTEM
MODEL		ANCHOR PRESS MUCK SYSTEM
MACHINE		ANCHOR P

CONVENTIONAL EXCAVATION

EXPLOSIVES, POWDER FACTOR 4LB/CY TOTAL LBS 365 PKIMERS, 25LB I.SIN X BIN, 60-75PCT THIN 25LB 7/8IN X 16IN, 30PCT INTERIOR ANFO CUT 40LB I.SIN X 16IN, 45PCT LIFTERS ANFO
HACHINE JUMBD 3 EOGN JUMBD 3 EOGN HACHINES GAPONEH DENVER DEPTH 10.5FT 3-PH123 ORIFTER OIAM, 1-3/4IN FEED LENGTH 12FT SF/HOLE 5.4
MACHINE JUMBO 3 FOGN MACHINES GAPONEH O 3-PH123 O FEED LENGTH 12FT

MUCKING SCOOFTR

	4.2	~	SPES				TER AT HOIST	D.V.	
	**************************************	S.0	A=ANGULAM S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=5		OUGHNESS NOEX	0.73	SIZE(-)2.0 ANGLE INTER FRICTION DEGREES AT	37	
<b>4</b> 2	0010N		GULAR E≖E	-19	TOUGHNESS	ô	MOIST 3		
¥.	NO30 NO50	0.9	C I=IRRE	4	FLOW INDEX	S.S0	ASITY PCT PCT	100	
¥.	•	8	Y C=CUBI	4	Z	vi	BULK BULK BENS HOIST 0.0		
92	SCREENS.	8.0	ED P=PLAT	4	STICITY EX	S	APPARENT COMESION PSF AT 0 PCT	\$2	
35	F BETWEEN NOB	7.0	R=ROUNDE	•	ATTERHERG LIMITSSIZE(-) 0.056IN. TIC SHAIMKAGE PLASTICITY LIMIT PCT PCT	\$0°			
165	N. ZIN. IIN. IZZIN. NO4	20.0	UBANGULAR	Id	LIMITS	39.68	SLIDE PLATE S AT T MOI	80	
	PER CENT	14.0	יטראע S=5	ď	TTERRERG SHB LIP	ent .	SIZE		
	ZIN	6.0 I3.0		4	PLASTIC LIMIT PCT	50.05	ANGLE/MEPOSE 10 IN DROP DEGGES AT	Δ,	
	O N O N O N O N O N O N O N O N O N O N	0.0	ZEEN SIZE		ŭ 73		ANGLE IO IN DEGGE	32	
	PCT(+)6 +.		BETKEEN SCREEN SIZES		LIQUID LIMITS PCT	25.00	AREPOSE OROP ES AI		
		0.0			5F .S12E		ANGLE 1 IN 0EGPE 3.4 P	33	٠
	MOISTURE PCT	16.8	SHAPE OF FRACTIONS		POT VOL CMANGE (-)0.056 IN.SIZE		(-10.0S6IN.SIZE SPECIF GRAVITY		
	CK OATA	76	SHAPE		PoT v	0	SPECII GRAVII	2.67	

SPHERCID

PCT (-) NO7J0

SHORE MOH SCHMIDT

R00 PCT EST

COMPR STRN TH KPSI

ROCK PROPERTIES IGNEOUS: BIOTITIC GUARTZ HONZONITE, FINE TO MEDIUM GRAINED PORPHYRY

KEY IDENTIFICATION IO LK

SAMPLE NO

11.0

MUCK DATA DRY UNIT

LK-5

NCY 104 TUNNEL 04TA

	ECONOARY 440V		
	PUTER STSTEM PRIMARY SECONDARY 440V		SHOTCRETE
UT TAY I TAKE	AIR WATER PUMP		SET + SIZE + SHAPE NONE
WATER INFLOW	GPH		ROOF PLATE
	SIZE HP	SUPPORT SYSTEM	BOLT.TYPE SIZE ROOF PLATE
VENTILATION	PRESS EXHST		SUPPLY DIESEL TRUCK
VENT	GRADE CFM VERT NONE		PERSONNEL O I ESEL TRUCK
TUNNEL	SIZE SHAPE 12FT ROUND I3-7/BIN PILOTHOLE	HAULAGE SYSTEM	MUCK WAGNER ST-8 SCOOPTWAM RAIL SKIP

MACHINE EXCAVATION

THRUST. HAX/OPERATE KLB BI4 KLB 490- S10	
MEAD CENTER SETTLE NETLE SETTLE	
RPH HEAD CEATER	
CUTTERS.MAKE.TYPE.UIAM.CUTTING EDGE'S CENTER I ROBBINS. IIIN IY ROBBINS 12IN 3 ROBBINS, I2IN STL OISC.2-IIIN SIEEL DISC.2-II STEEL DISC DISC	STEM GUIDANCE THRUST/SO FT SURVEY IN PILOT KLB 4.46 HOLES
CUTTERS.MAKE.TYPI CENTER I ROBBINS, IIIN STL OISC.2-IIIN	POWER SYSTEM ELECTRIC MOTORS 3-100 HP
MACHINE MAKE HODEL WT ROBBINS HBIR RAISE 49 DRILL TONS	ANCHOR PRESS MUCK SYSTEM GRAVITY

CONVENTIONAL EXCAVATION

BLASTING	
EXPLOSIVES, POWDER FACTOR TOTAL LBS	TRIM INTERIOR CUT LIFTERS
ROUND. NO. MOLES DEPTH OIAM.	CUT.
MACHINE JUHHO MACHINES	FEED LENGTH

HUCKING

				PCT (-)	16.0
				NO200	
	SCHMIOT	A		00 E ON	6.0
	SHORE MOH SCHMIOT	₹ Z		K050	7.0
	SHORE	<b>«</b>		N030	0.8
	PCT EST	86 MENS G	o .	SCREENS.	1.0 II.
	STRNTH KPSI FSI	TEST SPECIMENS BROKE ALONG	JOINTS DUR	6IN. 3IN. ZIN. IIN. I/ZIN. NO4 NO8 NOI6 NO30 NOS0 NP330 NO200	19.0 12.0 11.0 11.0 8.0
č	PET	137		T BY WEIG	19.0
				PER CEN	9.0
21041	EUIUM			ZIN.	0.0 0.0 I.0 9.0
ES TTTC OF	VE TO W			3IN.	0.0
OPERTI	PORPH GLEO JO			6 IN.	9
I GNEOUS	MONZONITE. FINE TO MEDIUM GRAINED POMPHYRY. FREUDENT FLAT ANGLEO JOINTS.			PCT(+)6 IN.SIZE	0.0
ICATION	04			MOISTURE PCT(+)6 PCT IN.SIZE	16.8
AET IDENTIFICATION II LK	SAMPLE NO		UCK DATA	DEY UNIT	06
Ž			2		

XEY 11

SHAPE OF FRACTIONS DETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID

AI

TOUGHNESS	0.31	SIZE(-) 2.0 IN. ANGLE INTER FRICTION DEGREES AT 0.2 PCT MOIST	
FLOW INDEX	4.00	BULK BULK PCF AT 0.0 OCT MOIST	:
PLASTICITY INDEX PCT	1.24	APPARENT BULK COMESION DENSITY PSF AT PCF AT 0.2 PCT HOIST 0.0 UCT MOIST	
PLASTIC SHRINKAGE PLASTICITY STATE PLASTICITY LIMIT LIMIT PCT PCT	17,27	ANGLE/REPOSE ANGLE/SIDE IN ANGLE/REPOSE ANGLE/SIDE IO IN UROP STEEL PLATE DEGREES AT DEGREES AT 3.7 PCT MOIST	32
		ANGLE-REPOSE ANGLE-REPOSE IO IN UNOP DEGREES AT 3.7 PC! MOIST	59
IZE LIDUIO LIMITS PCT	19.40	ANGLE/PEPUSE I IN DROP DESTRES AT 3.7 PCT MOIST	30
POT VOL CHANGE (-)0.056 IN.SIZE	0	SPECIF ANGLE/REPUSE ANGLE/REPUS	2.53

	DATA
KEY	11A TUNNEL

PRIMARY SECONDARY POWER SYSTEM SHOTCRETE AIR WATER PUMP SET. SIZE. SHAPE UTILITY LINES WATER INFLOW BOLT. TYPE SIZE ROOF PLATE NONE GPN SUPPORT SYSTEM <u>Q</u> CFM PRESS EXHST SIZE NONE SUPPLY DIESEL TRUCK VENTILATION PERSONNEL. DIESEL TRUCK GHADE SIZE SHAPE 4FT ROUND I3 7/8IN PILOTHOLE HAULAGE SYSTEM MUCK WAGNER ST-8 SCOOPTRAM RAIL SKIP TUNNEL

#### MACHINE EXCAVATION

THRUST . MAX/OPERATE		KL8 220	
TORQUE.MAX/OPERATE	-EAD CENTER	KFTLB 583 KFTLB KFTLB 260 KFTLB	
RPM	HEAD CENTER HEAD		
CUTTERS.MAKE.TY	I ROHBINS IZIN		POWER SYSTEM GUIUANCE THRUST/SQ FT ELECTRIC SURVEY MOTORS IN PILOT KLH 17.2 3-100 MP HOLE
	ROBBINS HBIR ARISE 49	OFILE IONS	ANCHOP PRESS MUCK SYSTEM GRAVITY KLB

## CONVENTIONAL EXCAVATION

EXPLOSIVES, POWDER FACTOR TUTAL LBS	TRIMERS. INTERIOR CUT
ROUND, NO. HOLES DEPTH	
MACHINE JUMBO MACHINES	FEED LENGTH

GUIDANCE

MUCKING

BLASTING

	-	717	
	T CCDT	1 254	

	PCT (-)	<b>*</b> .3	P=SPHERO10		. IN.	A Ser
SCHMIDT NA	NOSO NOIDO NOSOO	I.2	AR E=ELONGATED S	TOUGHNESS INDEX 0.18	SIZE(-) 2.0 1 ANGLE INTER FRICTION DEGREES AT 0.2 PCT MOIST	***
SHORE HOH SCHMIDT	NO30 NOSO	1.9 1.2	=CUBIC I=IRREGUL	INDEX S.00	BULK OENSITY PCF AT I 0.0 PCT MOIST	м 11 <b>4</b>
COMPR ROD STRNTH PCT CKPS1 EST		3.7 3.1	JUNDED P=PLATY C: A A	PLASTICITY INDEX PCT	APPAKENT COHESION PSF AT 0.2 PCT MOIST	0.2
DRY CO	21N. 11N. I/21N. NO4 NO8 NOI6	5 14.2 4.3	A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID	PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT INDEX PCT PCT 17.04 0.88	SIZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE OEGREES AT 1.7 PCT NOIST	88
PERTIES QUARTZ MONZONITE QUARTZ MONZONITE * INTENSELY ALTERED RAINED	3IN.	0 11.2 12.3 15.5	SCREEN SIZES A=ANGULAR :	PLASIC LIMIT PCT 17.12	ANGLE-MEDOSE  ANGLE-MEDOSE  10-IN UNDO  OEGREES AT  1-7 PCT MOIST	5\$
ROCK PROPERTIES IGNEOUS: GUARTZ PORPHYRY. INTEN	PCT(+)6IN.SIZE 61≅5	13.1 14.0	•	Liguio Limits PCI 18.00	ANGLEZREPOSE 1 IN UROP OEGFEES AT 1.7 PCT MOIST 1	
12 LK 12 LK Sample NO LK-7	ATA	107 9.7	SHAPE OF FRACTIONS BETHEEN	POT VOL CHANGE (-) 0.056 IN.SIZE 0	(+)0.75 IN.SIZE SPECIF GHAVITY I OF	2.6R 2

PRIMARY SECONDARY 4160 220	DO CO 100-000 1	SHOTCL ZTE	,	OPERATE THRUST. MAX/OPERATE	CENTER KLB KF1LB KF7LB KF1LB			GUIDANCE GUIDANCE LASER
AIR WATER PUNP 6IN 2IN 4IN		SET.SIZE.SHAPE		APH TORQUE, HAX/OPERATE	HEAD.CENTER HEAD KFTLE KFTLB			BLAST ING CLICT STOLL 0-15 PERSON
GPH HINGR	1000	HOUF PLATE			GAGE	THRUST/SQ FT ALB		FXPLOSIVES. POWDER FACTOR 4.7 LB/CY TOTAL LBS 350 PRIMERS. 25LB. 1.5XBIN. 60PCI TRIM 25LB.7/BX16IN. 30PCI INTERIOR CUT
1 SIZE HP 48IN 150	SUPPORT SYSTEM	bolt.type size 6FTx3/4IN#4FT		CUTTERS.MAKE.TYPE.DIAM.CUTTING EGGES	INTER) OR	GUIDANCE THE		FXPLOSIVES: POWDER FACTOR TOTAL LBS 350 PRIMERS: 25LB: TRIM 25LB:7/8) INTERIOR CUI
CFN PRESS EXHST 22K X		SUPPLY DIESEL · TRUCK		CUTTERS.MAKE.TYP	CENTER	POWER SYSTEM		ACUMO. MOLLS COPPLETE
E GRADE E0 -26PCT		PERSONNEL DIESEL TRUCK	MION		)EL	MUCK SYSTEM	XCAVATION	
SIZE SHAPE 15FT X ARCHEO 14 FT BACK	HAULAGE SYSTEM	MUCK WASHER ST-8 SCOOP TABM RAIL SKIP	MACHINE EXCAVATION	MACHINE	HAKE MODEL	ANCHON PRESS KLB	CONVENTIONAL EXCAVATION	MACHINE JUMBO 3 BOOM MACHINES PR-123 FEED LENGTH 12FT

POWER SYSTEM

UTILITY LINES

WATER INFLOW

VENTILATION

12A TUNNEL DATA

TUNNEL

٠		
	SHORE MOH . SCHIDE	1
	SHORE	
	PCT EST	20
	STRNTH KPSI	19
700	PE	165
ROCK PROPERTIES	MONZONIE COURSE GRAINEO WITH MANY SULFIDE, VEINLETS HIGHY FRACTURED, DUDNINGMETS	ORTHOGONAL FAULTING
KEY IDENTIFICATION	SAMPLE NO	

	PCT (-)	2.2
	6IN. 3IN. ZIN. IIN. 1/ZIN. NO4 NO36 NO16 NO50 NO50 NO200 NO200	
SHORE HOH SCHILLE	W0100	7 0.7
H 0	NO50	1.0
SHORE	N030	1.5
PCT EST 50	CREENS.	10.8 3.7 14.8 17.0 14.0 5.9 3.0 2.2
STRNTH KPSI 19	BETWEEN S	.9
PCF 65	WE I GHT	5 0.4
¥T PCF 165	SENT HY IZZIN•	•
EO	PER	14.8 II
GRAINE E VEIN PRONUL ING	21.2	3.7
MONZONITE COURSE GRAINEO WITH MANY SULFIGE, VEINLETS WIGHLY FRACTURED, PRONGUNCEO ORTHOGONAL FAULTING		10.8
MONZONI WITH MA: HIGHLY I	PCT(+)5 IN-S17E	5-15
0	ATA MOISTUNE P	1.1
SAMPLE NO	OCK OATA	76
	00 G	

SMAPE OF FRACTIONS BETHEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=KGUNOED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPMEROID

TOUGHNESS INDEX INDEX 0.29 SIZE(-) 2.0 IN. ANGLE INTER FRICTION DEGREES AT DEGREES AT TO 0.2 PCT MOIST	3
MNESS X X 29 512E(-) 2.0 ANGLE INTE FRICTION DEGREES AT	1
MNESS. 29 312E(+ ANGL DEGRE	1
32	
# MOIST	
S.1 S.1 BBUCK BBUCK PCF AT	112
0 15	
PLASTIC SHWINKAGE LEMITS.SIZE(-) 0.056IN.  PLASTIC SHWINKAGE PLASTICITY FLOW T  LIMIT LIMIT INDEX INDEX INDEX  ILOZ 10.52 I.48 5.1  IL.02 10.52 I.48 5.1  VOLEZKEPOSE ANGLESLIDE APPARENT BULK  EGHEES AT DEGREES AT PSF AT PCF AT  PCI MOIST 0.2 PCT MOIST 0.0 PCT MOIST	96
PLAS INOG PCT 1.48	
BERG LIMITSSIZE. SHUNKAGE LIMIT PCT 10.52 10.52 ZE(-)2.0 IN STEL PLATE DEGREES AT 0.2 PCT MOIST	
PLASTIC SHERG LIMIT PLASTIC LIMIT SHAINKA(LIMIT PCT LIMIT PCT II.02 I0.52 ANGLE/SL ANGLE/SL BEGWEES AT DEGREES CT MOIST 0.2 PCT	58
L SIZE	
LASTIC IN LT CT CT CT CT CT CT CT CT CT CT CT CT CT	
PLASTIC LIHIT PCT II.02 II.02 ANGLE/MATERIAL ANGLE/MOP DEGWEES AT 0.2 PC! MOIST	10
av	
12.50 12.50 12.50 12.50 12.50 17.50 18.50 18.50 18.50	
POT VOL CHANGE  (-)0.056 IN.SIZE  LIMIT  PCT  0  I2.50  SPECIF  ANGLE/REPOSE  GFAVITY  DEGFEES AT  0.2 PCT HOIST	9
IN.SI	
POT VOL CHANGE  (-) 0.056 IN.51ZE  0  -) 0.75 IN.SIZE **  GRAVITY  DE( 0.2	
(-) 0 (-) 0.7 SPECI GRAVI	

KEY 13a TUNNEL DATA							٠		
TUNNEL		VENT	ENTILATION			MATER INFLOW	UTILITY LINES	PONER SYSTEM	stre
S17E SHAPE 12FT X RECT 12FT	GRADE +0.4PCT	CFM 14K	PRESS EXHST	S12E 241N	# 0 # 0	GPH NONE	AIR WATER PUMP 4IN 2IN 8IN	ag e	SECONOAST 468
HAULAGE SYSTEM				SUPPOR	SUPPORT SYSTEM	·			
MUCK FAIL 10 TON GOTTOM DUMP 36 IN GAGE 45 LB	PERSONNEL		SUPPLY	dOLT+1	dOLT.TYPE SIZE	ROOF PLATE	SET.SIZE.SHAPE 121N H BEAN 10FTXIZINXIZIN POSTS # SFT	SHOTCRETE	
PACHINE EXCAVATION	70								
MACHINE		CUTTE	CUTTERS, MAKE, TYPE, UIAM, CUTTING EDGES	UIAM.C	UTTING ED	GES	RPH TORQUE. MA	TORQUE. MAX/OPERATE	THRUST . MAX/
MAKE MODEL	=	CENTER		INTERIO		GAGE	HEAD CENTER HEAD	CENTER	1
							KFTLB KFTLB	KFTL8 KFTL8	. K8
ANCHOR PRESS M	MUCK SYSTEM	ž	POWER SYSTEM	GUIDANCE		THRUS1/50 FT	7	6. 40	, , , , , , , , , , , , , , , , , , ,
KLB			,		KE8			çılı	
					į		PA 44 14		
CONVENTIONAL EXCAVATION	AVAT169	,		ij			•	**	8
MACHINE JUMBO 3 ROOM MACHINES CF79 OR 0 89 FEED LENGTH 6 FT	Falency's Designation	DEPTH S	# 5 E	WALALIOJ	EXPLOSIV POUDER F TOTAL LB PRINERS. TRIM AND CUT ANTEL	100 3. 4. 8. 4. C. 7. 100 3. 4. 8. C. 7. 100 3. 4. 8. C. 7.	BLASTING IGNITER CORD FUSE, NO 6 CLPS	MUCKING EIMCO 40 LOADER	GUIDANCE

		PCT (-)	1.8
		00Z00	
SCHMIDI	<u> </u>	61N. 31N. 21N. 11N. 1/21K. NO4 NOB NOIG NOSO NOSO NOSO NOSO	5.4
SHORE NOH SCHMIDT	ž	NO50	5.6
SHORE	ď Ž	N030	6.8
ROD PCT EST	9	SCREENS	11.2 8.5 6.8
COMPR STRNTH KPSI	•	BETWEEN S	8.1 11
DRY WIT PCF		N. WEIGHT	0.0 0.0 0.0 4.8 37.8 18.1
0	 	ER CENT B	8.
ROCK PROPERTICS HETAMORPHIC: GRANITIC GNEISS, HIGHLY METAMORPHOSED, HODERATELY TO HIGHLY FRACTUPED, HIGHLY SIL'CIFIED,		ZIN. 11	0.0
TICS • GRANII MORPHOSE TO HIGHL HIGHLY S		3IN.	0.0
K PROPER AMOMPHIC HLY META ERATELY CTUPEU:			Ü
ROCCI HETA HOUN		PCT (+)6 IA.SIZE	0.0
IDENTIFICATION CLIMAX SAMPLE NO CL-1		MOISTURE PCT	8.8
		OHY UNIT	87
KEY 14		2.	

SMAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPMEROID

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		IN. IN. IN. IN. IN. IN. IN. IN. IN. IN.	
DESCESS.	3	SIZE(-) IN ANGLE INTER FRICTION DEGREES AT PCT HOIST	¥
E M	-77	BULK DENSITY PCF AT PCT M015T	-
FLOW	¥	BULK DENSITY PCF AT	¥ N
PLASIC SHRINKAGE PLASICITY LIMIT LIMIT PCI PCI	44	IN APPARENT E COMESION OPS AT IST PCT WOIST	Z
ITSSIZE (- AGE		ANGLE/SLIOE STEEL PLATE DEGREES AT PCT HOIST	
ERBERG LIM SHRINK LIMIT PCI	<b>4 2</b>	SIZE(-) ANGLE/S SIEEL DEGREE	Ž
PLASTIC LIMIT PC1	₹ 2	ANGLE/KEPOSE ANGLE/ ANGLE/KEPOSE ANGLE/ IO IN UNOP STEEL DEGREES AT DEGREE PCT MOIST PC	A
LIGUID LIMITS PCT	₹ Z	IN.SIZE ANGLEREPOSE I IN DROP DEGFEES AT PCT MUIST	<b>4</b> 2
POT VOL CHANGE		IN.SIZE +.	
POT VOL	₹ Z	SPECIF GPAVITY	N.

*312*	SECOMBARY		
S WINDS	PHINARY 41567		SHOTCRETE
UTILITY LINES	AIR WATER PUNP 4IN 2IN		SET.SIZE.SHAPE
WATER INFLOW	6PH 5-10		ROOF PLATE
	SIZE HP 24IN	SUPPORT SYSTEM	HOLT TYPE SIZE ROOF PLATE WONE
VENTILATION	CFM PRESS EXHST		SUPPLY
VE	GRADE CF +0.25PCT 10		PERSONNEL RAIL
TUNNEL	SIZE SHAPE I3FT ROUND	HAULAGE SYSTEM	RUCK

KEY I4a TU'INEL DATA

THRUST . HAX/OPERATE		KLB 133 KLB 130
TORQUE.MAX/OPERATE	HEAD CENTER	FFTLB 347 KFTLB KFTLB KFTLB
RPM	HEAD CENTER HEAD	9
CUTTERS, MAKE, TYPE, DIAM, CUTTING EDGES	MODEL WI CENTER INTERIOR GAGE 1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2	TONS TRICONE, 24IN GTMHB ROLLER
MACHINE	0	

	EXPLUSIVES. PUMOER FACTOR TOTAL LBS PRIMERS. INTERIOR LIFTERS
VATION	ROUNO. NO. HOLES OEPTH OIAM.
CONVENTIONAL EXCAVATION	MACHINE JUMBO MACHINES FEED LENGTH

CUIDANCE

HUCKING

BLASTING

MACHINE EXCAVATION

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CURRENT	

LK-3

		PCT (=)	2.3	D SP=SPHEROID				O IN.	
SS	<b>4</b> 2	NO30 NOS0 NO100 ND200	***	A=ANGULAR S=SUBANGULAR R=KOUNOEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID	1	FLOW TOUGHNESS INDEX	90.0	SIZE(+)2.0 ANGLE INJER FRICTION DEGREES AT ST 0.4 PCT MOIS	14
• HARONES MOH	4 2	NOS0	0	I= I RREGU	, 14	× ×		SITY AT PCT HOIST	117.8
SHORE MOH SCHMIOT	¥ 2	NO30	80	C=CUBIC	I	FLOW	S.50	PCENT	
Roo PCT EST	000	CREENS.	6 1.2	PEPLATY	IV	Desticity Index		APPARENT COHESION PSF AT	175
COMPR STRNTH KPS1	56	WEIGHT BETWEEN SCREENS	2.8 1.6	R=K <b>O</b> UNOEO	I AI	IZE(+) 0.0 PLAST INOEX PCI	0.33		
0 ≥ 9 7 1 2 7 7	178	•	F.8	≠SUBANGULAR	AI AI	LASTIC SHRINKAGE PLINITS.SIZE(-) LASTIC SHRINKAGE PL IMIT LIMIT CT PCT	17.80	SIZE(-)2.0 IN ANGLE/SLIDE SFEEL FLATE DEGREES AT 1.5 PCT MOIST	62
ERED ARTZITE LY TO SEDIMENTS	ETITE AND	ZIN. 11N. 1/21N	10.2 10.6	A=ANGULAR S	Al AI	ATTERBES	95	TERIAL SIZE EPOSE . ROP AT MOIST I	
TIES : INTERLAY! BETWEEN QU • MODEKATE! EKED META.	PLACEMENT PYRITE. YRITE AND MAGNETITE AND PERCENTAGE OF SILICATES NE TO MEDIUM	318.	17.4 9.1	SCREEN SIZES	Al AI	PLASTIC LIMIT PCT	17.92	ANGLE/MEPOSE ANGLE/MEPOSE 10 IN UROP DEGPEES AT 1.5 PC1 MOIST	62
MOCK PROPERTIES METAMURPHIC: INTERLAYERED TPANSITION BETWEEN QUARTZITE AND TACTILE, MODERATELY TO STRONGLY ALLERED METASEDIMENTS	WITH REPLACEMENT PYRITE. CHALCOPYRITE AND MAGNETITE A HIGH PERCENTAGE OF SILICY VERY FINE TO MEDIUM GRAINED.	PCT(+)6 *	34.1		VI V	LIGUID	18.25	ANGLE/AEPOSE IN DANDH DEGREES AT I.S PCT MOIST	30
1CATION NO		MO1STURE PCT	0.1	SHAPE OF FRACTIONS BETWEEN		POT VOL CHANGE (+)0.056 IN.SIZE		IN.512E	
SAMPLE NO		MUCK DATA DRY UNIT AT PCF	105	SHAPE		10V TOG (-)	0	SPECIF GPAVITY	3.21

		WATER INFLOW	GPM		ROOF PLATE 13.51N X 9FT
			нР 150	SUPPORT SYSTEM	bolt type Size 3/4in x 6ft At 4ft
			SIZE 487N	SUPPORT	60LT.TY
			EXHST		
		VENTILATION	PRESS EXHST HEAD SURF		SUPPLY DIESEL TRUCK
		VENT	SZK		
			GRADE +2.0PCT		PERSONNEL DIESEL TRUCK
	DATA		SIZE SHAPE 16FT X ARCHED 14-1/2FTTBACK	SYSTEM	51-8 4M 11P
KEY	15A TUNNEL DATA	TUNNEL	SIZE 16FT X 14-1/2F	HAULAGE SYSTEM	MUCK WAGNER ST-8 SCOOPTRAM

AIR WATER PUMP

UTILITY LINES

SHOTCRETE

SET.S1ZE.SHAPE

	THRUST.MAX/OPERAT	7 2 6 6
	TORQUE.MAX/OPERATE HEAD CENTED	KFTLB
	TORGUE.	KFTL8
	RPM TOROL HEAD.CENTER HEAD	
	16 EDGES GAGE	
	CUTTERS, MAKE, TYPE, UIAM, CUTTING EDGES CENTER INTERIOR GAG	
	CUTTERS,MAKE CENTER	
	3	
MACHINE EXCAVATION	MODEL	
MACHINE E	MACHINE	

THRUST/SO FT	KLB
GUIDANCE	
POWER SYSTEM	
MUCK SYSTEM	
ממשא המנומיי	KLB

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BLASTING ELECTRICAL 0-15 REGULAR		
EXPLOSIVES. POWDER FACTON SLB/CY TOTAL LBS 205 PRIMERS, 1518 1.51N X RIM. 40-74-001	TRIM ISLG 7/81N X 161N+ 30PCT	LIFTERS ANFO
ROUND.  NO. HOLES 42 P  DEPTH 6FT  TIERS DIAM. 1-3/41N P	CUI+ 6 HOLE BURN 1-4IN CNTR HOLE	SF/HOLE 5.0
MACHINE JUMBO 3 GOOM MACHINES 3-PR123 DRIFTERS	FEED LENGTH 12FT	

	PCT (-)	6.5
ESSSCHMIOT	NO 100 NO 500	80.00
SHORE MOH SCHWIOT	NOSO	0.0
SHORE	N030	9.8
ROO PCT EST 70 70 SINED*	CREENS	1.6 1.2
COMPR. F STRNTH FRSI EST 14 TEST SPECIMENS BROKE ALONG STEEP INCLINE STEEP INCLINE PREPARATION.	BETWEEN S	I.6 I.
P P CF	BY WEIGHT	7.3
ROCK PROPERTIES METAMORPHIC: TACTITE STRONGLY ALTERED CALCAREOUS META- SEDIMENTS, WITH REPLACEMENT PYRITE. CHALCOPYRITE AND HAGNETITE AND A HIGH PER- CENTAGE OF SILICATES, FINE TO VERY FINE GRAINEO.	51N. 31N. 21N. 1/21N. NO4 NO8 NO16 NO30 NOSO NO100 NO200	19.3 13.7 13.9 9.8
	PCT(+)6 IN.SIZE	26.3
ICATION NO	IT MOISTURE F PCT	2.1
SAMPLE NO LK-4 LK-4 MUCK DATA	DRY UNIT	124
_		

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A MANGULAR S SURANGULAR R MOUNDED PEPLATY CHCUBIC INTREGULAR EMELONGATED SPASPHEROID

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TOUGHNESS	0.19	SIZE(=) 2.0 IN. ANGLE INTER FRICTION OEGREES AT 1 0.2 PCT HOIST	Ç.
FLOW	S.40	BULK PCF SITY PCF AT HOIST	115
E(-) 0.0S6IN	1.05	APPARENT BULK COHESION OENSITY PSF AT PCF AT 0.2 PCT MOIST 0.0 PCT HOIST	165
PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT LIMIT PCT PCT	10.44	ANGLE/REPOSE ANGLE/SLIDE ID IN UNOP STEEL PLATE OEGMEES AT DEGREES AT 2.0 PCT MOIST 2.0 PCT MOIST	30
PLASTIC LIMIT PCT		ANGLE/REPOSE 10 IN UNOP OEGREES AT 2.0 PC1 MOIST	35
LIGUID PCT PCT	19,00	GOFES AT	37
POT VOL CHANGE (-)0.056 IN.SIZE	0	(-) 0.75IN.SIZE *SPECIF SPECIF GRAVITY DEGFES AT OF 2.0 PCT MOIST D.	3.36

L.K-4

	DATA
KEY	16A TUNNEL

STEM	SECONDARY 220V			
POWER SYSTEM	PRIMARY 4160V		SHOTCRETE	
UTILITY LINES	AIR WATER PUMP 6IN 2IN		ACT-SIZE-SPORE	
MATER INFLOW	GPH NONE		ROOF PLATE	
	SIZE HP	SUPPORT SYSTEM	JOLT . TYPE SIZE	NONE
PENTILATION	CFH PRESS EXHST SOK HEAD SURF		SUPPLY	TRUCK
الما	GRADE +2.0PCT		PERSONNEL	TRUCK
TUNNEL	SIZE SHAPE ISFT X ARCHEO 14F; BACK	HAULAGE SYSTEM	HUCK	SCOOPTRAN RAIL. SHIP

MACHINE EXCAVATION

OPERATE		
THRUST. HAX/OPERA		KL8 KL8
RQUE.HAX/OPERATE	CENTER	KFTLB KFTLB
TORQUE.N	HEAD	KF1L8 KF1L8
# <b>d</b> %	EAO.CENTER	
	-	
ખેલ EDGE\$	GAGE	
E.TYPE.UIAM.CUTTING EDGES	INTERIOR	
S. HAK	CENTER	
	3	
	MODEL	
HACHINE	MAKE	

GUIDANCE THHUST/SQ FT POWER SYSTEM ANCHOR PRESS HUCK SYSTEM

KLB

CONVENTIONAL EXCAVATION

MACHINE	ROUNO.	EXPLOSIVES.
JUMBO 3 500M	NG. HOLES 42	PUNDER FACTOR
MACHINES GARDNER DENVER	R DEPTH 6 FT	TOTAL LBS 205
3-PRI23	01AM. I-3/4IN	PHIMERS, ISLE
DRIFTERS	CUT. 6 HOLE BURN	TRIM ISLB 7/8
FEED LENGTH 12FT	1-4IN CENTER	INTERIOR ANFO
	HOLE	CUT 25LB 1.51
	SF/HOLE 4.4	LIFTERS ANFO

BI .5IN X BIN. 60-75PCT BIN X 16IN. 30PCT IN K IGIN. 45PCT 3 5.5LB/CY

MUCKING SCOOPTRAM

		PCT (-)	16.3	P=SPHER010				1N°.	
• MIOT	g E	N0100 N0200	1 • I	A=ANGULAR S=SUBANGULAR R=ROUNDEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID		TOUGHNESS	0.66	S1ZE(+)2.0 1 ANGLE INTER FRICTION DEGREES AT 6.9 PCT MOIST	38
SHORE MON SCHMIOT		050N	I.8 I.3	IIC I=IRREGULA	AI AI	FLOW	I • •	BULK BULK DENSITY PCF AT 0.0 PCT MOIST	141
PCT SHORE		SCREENS	e. e.	P≖PLATY C≠CUE	H			ARENT FESION AT PCT MOIST 0	235
COMPR STRNTH KPSI		BETWEEN	10.3 7.4	LAR R=ROUNDEO	AI AI	**************************************	2.1	9 ••••••••••••••••••••••••••••••••••••	
ORY WI PCF		PEP CENT BY WEIGHT ZIN. IIN. I/ZIN. NO4	II.4 20.I	LAR S=SUBANGU	AI	TERBERG LIMITS SHRINKAGI LIMIT PCT	13.9	SIZE(-)2.0 ANGLE'SLIDE STEEL PLATE DEGREES AT 6.2 PCT MOT	31
	9 PCT, SILICA S PCT	3IN. ZIN. II	1.4 8.7		AI AI.	PLASTIC LIMIT PCT	15.1	**************************************	35
ACCK PROPERTIES AETAMOMPHIC: INTER LAYERED BANDS HEWATITE AND MAKITTE HIGHLY JOINTED NORMALLY FL. LYING, UFTEN HIGHLY FLUDEO NATURAL IRON OVER 60 PCT	MOISTURE 9 PCT	PrT(+)6	6.4	SHAPE OF FRACTIONS RETWEEN SCREEN SIZES	A	LIGUID LIMITS PCT	17.8	SE	
	•	MOISTURE Pro	7.2 7.2	F FRACTIONS 8	A	POT VOL CHANGE (-)0.056 IN.SIZE			37
KEY IDENTIFICATION I7 MATHER B SAMPLE NO 48-1		MUCK OATA	128	SHAPE 0		POT VOL (-) 0.05i	o	(*)0.75 IN.SIZE SPECIF GPAVITY	4.34

CURRENT: I SEPT. 1972

HB-I

	DOUBLE CYCLE	PRIMARY SECONDARY		SHOTCRETE
,	UTILITY LINES	d.		SET.SIZE.SHAPE 9FT 6IN DIA. X 4IN WF AT 4SIN
	WATER INFLOW	GPN		ROOF PLATE
		SIZE HP BIN S	SUPPORT SYSTEM	BOLT.TYPE SIZE ROOF PLATE
	VENTILATION	CFM PRESS EXHST 3K Å		SUPPLY RAIL HOIST
		GRADE 0.0		PERSONNEL PAIL MOIST
17A TUNNEL DATA	TUNNEL	SIZE SHAPE 9FI ROUND Il.SIN	HAULAGE SYSTEM	MUCK 42IN SCRAPER MAIL

KEY

THRUST MAY JOBEDATE		KLB 300 KLB 285
DROUE . MAX/OPERATE	AD CENTER	KFTLB 1290 KFTLB
RPM 10	HEAD.CENTER HEAD	KF
CUTTERS.MAKE.TYPE.DIAM.CUTTING EGGES	INTERIOR GAGE 258 CARBOLOY 20 CARBOLOY	
CUTTERS.	CENTER	
	MODEL WT	800
MACHINE	MAKE	

THRUST/SQ FT	KLB 3.66
GUIDANCE. SURVEY	
POWER SYSTEM REMOTE HYDRAUL.	PUMPS, Z-90GPM, 2500 PSI, Z-125 HP MOTORS
HUCK SYSTEM FLIGHT	TO REAR OF
ANCHOR PRESS	

	EXPLUSIVES. POWDER FACTOR	TAINERIOR INTERIOR CUT LIFTERS
NOTICE	ROUND. NO. HOLES DEPTH DIAM.	cur.
CONTENTIONAL EACHARITON	MACHINE JUMBO MACHINES	FEED LENGTH

GUIDANCE

HUCK ING

BLASTING

MACHINE EXCAVATION

SHORE MOH SCHMIOT	M
SHORE	
R0D PCT EST	10
COMPR STRNTH KPSI	₹Z
P = 0	<b>4</b>
ROCK PROPERTIES HETAMORPHIC: INTERLAYEREO HEMATITE AND MARTIE HIGHLY JOINTED, NORMALLY FLAT LYING, OFTEN HIGHLY	FOLDED, NATURAL IRDN 60 0/0, SILICA S 0/0
KEY IDENTIFICATION 18 MB SAWPLE NO MB-3	

			(-) LJ0	NO200
				NG200
				10100
				030 NOS0
			CREENS	NO16 NO
			BETWEEN S	NOB
			BY WEIGHT	1/21N. NO4
			PER CENT	11N. 1/
			**************************************	IN. 3IN. 21N.
			E PCT(+)6	
			MOISTURE	PCI
		JCK DATA	DRY UNIT	1 PCF
		Ĩ	_	-

SHAPE OF FWACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID

	IST
TOUGHNESS	SIZE(-) ANGLE INTER FRICTION OEGREES AT PCT MOIST
FLOW T INDEX	BULK BULK PCF AT PCF MJIST
PLASTICITY INDEX PCT	APPARENT COHESION PSF AT PCT MOIST
**************************************	IN. SLIDE PLATE IS AT
PLASTIC LIMIT PCT	ANGLE/REPOSE ANGLE, 10 IN UROP STEEL OEGMEE'S AT ULGREE PO
	(-) SPECIF GRAVITY DEGREES AT PCT WOIST
POT VOL CHANGE (-) IN.SIZE	(-) SPECIF GRAVITY

	SECONDARY 4+0			THRUST•MAX/OPERATE KLB 2-10 KLB		GUIDANCE
	PRINARY MED AND AND A	SHOTCRETE		TORGUE MAX/OPERATE HEAD CENTER KFTLB KFTLB		MUCKING
LITTI TTY I TMES	AIR WATER PUMP	SET+SIZE, SHAPE BIN-SULB WF SETS 7FI CAP, BFI POSTS WOOD LAGGING PIPE SPILING 8-1IN DIA-6-ZIN DIA		RPH TORQUE,MAX. HEAD. 60 KFTLB49 HP KFTLB		BLASTING
WATER INFLOR	SIZE HP	SUPPORT SYSTEM GOLT.TYPE SIZE ROOF PLATE		CUTTERS.MAKE.TYPE.UIAM.CUTTING EDGES CENTER INTERIOR GAGE 68 KENNAMETAL 43KH TC8 ON TWIN RIPPER HEADS	GUIDANCE THRUST/SQ FT TRANSIT KLH	EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS, TRIM INTERIOR CUT
VENTILATION	CFM PRESS EXHST	SUPPLY		CUTTERS, MAKE, TER CENTER 68 KENNAMETAL ON TWIN RIPPER	POWER SYSTEM	ROUND, NO. HOLES DIAM, CUI,
	PE GRADE	PERSONNEL RAIL	VATION	MODEL WIF	MUCK SYSTEM GATHERING AHMS•FLIGHT CONVEYORS	
TUNNEL	SIZE SHAPE 10FTX RECT 9FT 6 IN	HAULAGE SYSTEM MUCK 48IN SCHAPER 160 CF CARS 2-30T MOTORS 30 IN GAGE COU3 RAIL	MACHINE EXCAVATION	MACHINE MAKE MO ALPINE F-	ANCHOR PRESS KLB	CONVENTIONAL EXCAVATION HACHINE HACHINES FEED LENGTH

KEY 184 TUNNEL DATA

CURRENTE I SEPT. 1972 51-1

			î.
			PCT (-) NO260
			•
			N0200
SHORE KOH SCHMIDT	¥ Z		**************************************
, F			
7.7			Š
SHOR			N030
PCT EST	N.		NS.
	-		SCREE
COMPR STRNT: KPSI	•		EEN 08
STR	Z		ET N
			= .
DRY PCF			WEIG!
	Z Z		ZIN
			ENT
			Q Z
ر د ک	ğ		.PE
SHE	CR.		ż
A O	ACT		21
7 1			z
ARG UTC	RATE		~
C C C	3		ż
APH APH MO	Ĭ		
ROCK PROPERTIES METAMORPHIC: ARGILLIACEOUS OUARTZITE, MEUIUM TO THIN BEDDED, MODEWATELY TO MIGHLY	0.50		PCT(+)6 IN.SIZE
ROC OUA AED	던		1(+ .SI
			2 4
7			MOISTUME PCI
T10			1570
ICA			
ST ST SAMPLE NO			¥ 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
ST	-13	č	556
KEY I 9			MOCA UNIT
χ Π H			

SMAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S\*SUBANGULAR R\*ROUNDED P=PLATY C=CUBIC I\*IRREGULAR F=ELONGATED SP\*SPHERDID

	15 II
TOUGHNESS	LIRE(+) MIGLE INTER LICTION BEGREES AT PCT MOIST
N N N N N N N N N N N N N N N N N N N	BOLE DENGITE PCF AT PCF AT
INDEX	INAPPAHENT COMESION PSF AT PCT MOIST
**************************************	E/SLIDE L PLATE EES AT PCT MO)
PLASTIC LIMIT PCT	ANGLE/MEPOSE ANGLIO IN UROP STEEL OF STEEL OF STEEL OF STEEL OF UROR STEEL OF UROR OF
	ANGLE/REPOSE 1 IN DROP DEGREES AT PCT HUIST
POT VOL CHANGE (-) IN.SIZE	(-) IN.SIZE SPFCIF GRAVITY

	DATA
KEY	19A TUNKEL

POWER SYSTEM	PRIMARY SECONDARY 2300 480		SHOTCRETE
UTILITY LINES	AIR WATER FUMP		SET.SIZE.SHAPE
WATER INFLOW	GPM		ROOF PLATE 9FIXISIN MATS 21 BACK+ 21 EACH RIB
ITILATION	PRESS EXHST SIZE HP X	SUPPORT SYSTEM	SUPPLY BOLT: TYPE SIZE RAIL 6FTX: 751N 4/ HAT
TUNNEL	SIZE SHAPE GRADE CFM SFIXIO ARCH BACK +0.SPCT 7 FT 1.SIN	HAULAGE SYSTEM	MUCK 60 CF SIDE DUMP RAIL 40 LB RAIL 24 IN GAGE 6 T MOTOR

### MACHINE EXCAVATION

THRUST . MAX/OPERATE		KLB KLB
TORQUE, MAX/OPERATE	CENTER	KFTLB
TORQUE.N	HEAD	KFTLB KFTLB
RPK	HEAD.CENTER HEAD	
NG EDGËS	GAGE	
UTTERS, WAKE, TYPE, UIAM, CUTTING EDGES	INTERIOR	
CUTTERS, MAK	CENTER	
	12	
	MODEL	
MACHINE	MAKE	

14	
1/50	
THRUST/SO	KLB
GUIDANCE	
SYSTEM	
POWER	
SYSTEM	
MUCK	
PRESS	
NCHO9	•
A	7

# CONVENTIONAL EXCAVATION

EXPLOSIVES. POWGEN FACTOR S.4LB/CY TOTAL LB: 125 PRIMERS: 25LBS 60WR IX16 IN	TRIM NILITE INTERIOR NILITE CUT NILITE LIFTERS NILITE
ROUND. NO. HOLES 44 OEPTH 7 FT OIAM. 1 5/8 IN	CUT. BURNZ-4 IN
MACHINE JUMBO 3 BOOM MACHINES 2-583F	1-099 FEED LENGTH BFT

-	0	
	25.6	
•	-	
- Timbooil	* I E J K K C C	

CR-3

		PCT (-)
SSSSCHWIDT	AN	6IN. 3IN. 21N. 11N. 1/2IN. ND4 . NO8 ND16 ND30 NOSO NOIOO ND203
SHORE MOH SCHMIDT		OSON
ROD SHOT	0	NS ND3C
	u	EN SCREE
COMPR SIRNIH KPSI	Z	T BETWEE
DRY WT PCF	¥ N	BY WEIGH
URED		PER CENT
FZITE 1LY FRACT OR FILLED	15-90	21N•
RTIES IC: QUART FOLUED TO HIGH	DIPPING	N. BIN.
ROCK PROPERTIES METAWUPPHIC: QUARTZITE MODEWATLEY FOLUED MODEWATLEY TO HIGHLY FRACTURED /JOINTED WITH MINOR FILLED	VEINLETS. DESPEES	PCT(+)6 +. IN.SIZE 61
ICATICY NO		MOISTURE PCT
IDENTIFICATION CR SAMPLE NO CR-1		MUCK DATA DRY UNIT
> 0 ₩ ₩		203

SHAPE OF FRACTIONS BETHEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC 1=IRREGULAR E=ELONGATED SP=SPHEROID

à.	ž to
TOUGHNESS	SIZE(-) IN- ANGLE INTER FRICTION ' DEGREES AT PCT MOIST
FLOW	BULK DENSITY PCF AT PCT MOIST
PLASTICITY INDEX PCT	APPARENT COHESION PSF AT PCT MOIST
PLASTIC SHINKAGE PLAST INDEX PLAST LIMIT LIMIT INDEX PCT	SIZE(-) IN ANGLE/SLIDE STEEL PLATE DEGREES AT PCT MDIST
·	ANGLE/REPIAL SIZE(-) ANGLE/REPOSE ANGLE 10 IN UROP STEEL UEGREES AT DEGRE
CHANGE * IN.SIZE LIGUID PCT	IN.SIZE ************************************
POT VOL CHANGE	SPECIF GPAVITY

KEY										
20A TUNNEL DATA	ATA									
TUNNEL			VENTI	VENTILATION			MATER INFLOW	UTILITY LINES	POWER SYSTEM	TEH
S12E 10 FT 10 FT	SHAPE ROUNDEO CORNERS	GRADE +0.5PCT		CFM PRESS EXHST SIZE HP 135K X 24 IN 30	T 512E	30 12	GPN	AIR MATER PUMP 4 IN 2 IN 2 IN	PRIMARY 2360	PRIMARY SECONDARY 2360 460
HAULAGE SYSTEM	SYSTEM				SUPPOR	SUPPORT SYSTEM				
MUCK E1MCO 9128 L.M.O.	28	PERSONNEL LHD		SUPPLY	60LT.T 5 FT X # 3.5	YPE S12E 5/8 IN FT	60LT.TYPE SIZE ROOF PLATE 5 FT X 5/8 IN 9 FTX 13 IN # 3.5 FT	SET.SIZE.SHAPE	SHOTCRETE	

THRUST.MAX/OPERATE		W. R. R. W. R. R. R. R. R. R. R. R. R. R. R. R. R.
ORQUE.MAX/OPERATE	CENTER	KFTL8 KFTL8
TOROU	KEAD	KFTLB KFTLB
RPM	HEAD.CENTER	
•		
ić Euges	GAGE	
UTTERS.MAKE.TYPE.UIAM.CUTTING EDGES	INTERIOR	
CUTTERS.MAK	CENTER	
	14	
	HOOEL	
MACHINE	MAKE	

THRUST/SQ FT	KLB
GUIDANCE	
POWER SYSTEM	
MUCK SYSTEM	
ANCHOR PRESS	KLA
-	-

EXPLOSIVES. POWDER FACTOR 9.5 LB/CY TOTAL LBS 265 PRINTER.	TRIM NILITE INTERIOR NILITE CUT NILITE LIFTERS NILITE
HOLMD, NO. HOLES 48 DEPTM N PT	, too
HACHINE JUMBO 2 BOOM MACHINES D-93	FEED LENGTH BFT

MACHINE EXCAVATION

				PCT (-) NO200	3.0
	COOL CONTRACTOR CONTRA	C HOR SCHMIOI	42	61N. 3IN. 21N. 1IN. IZIN. NO4 NO3 NO15 NO30 NOSO NO100 NO200	1.5 9.2 13.2 13.3 10.4 3.2 2.0 1.2 0.7 0.5 0.5
	RBO		7.0	CREENS	0 1.2
	COMPR	KPSI	19	HT BETWEEN S	3.2 2.
	PK.	PCF	187	CENT BY WEIGHT	3.3 IO.4
	ITE WITH	F AULTING		ZIN. 1IN.	2 13.2 1
OPERTIES	PHIC: PHYLL!	HIGHLY METAMONPHOSED AND FOLDED. WITH MINOR FAULTING		61N. 31N.	6 5 6
ROCK PR	METAMOR VEINGUA	HIGHLY FOLDED.		PCT (+)6 IN.S17E	25.3
FICATION	LAKE	C		MOISTURE PCT	2.5
EY IDENTI	21 HOMESTAKE	SAMPLE NO HS-1	MUCK DATA	DPY UNIT	136

SHAPE OF FRACTIONS RETWEEN SCHEEM SIZES A=ANGULAR S=SUBANGULAR R=KOUNDEO P=PLATY C=CUBIC 1=IRREGULAR'E=ELONGATED SP=SPHERDID

STACK				NI TS	
THE CHARLESTER CHELCORAL ED SPRINGER		TOUGHNESS	1.01	SIZE(-)2.0 ANGLE INTER FRICTION DEGREES AT Z.0 PCT MOI	39
111111111111111111111111111111111111111	۷	FLOW INDEX	2.70	BULK DENSITY PCF AT 0.0 PCT MDIST	66
				MO1ST 0	
	Ve Ve	PLASTIC SHWINKAGE PLASTICITY LIMIT PCT PCT PCT		APPARENT COMESION PSF AT	160
	¥ d	IZE(=) O	2.74		
	d V	MITS.S	~	E(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 3.1 PCT MOIST	31
		KREKG LI SHKIN LIMIT PCT	15.12	ANGLE STEEL DEGRE 3.1 P	
	V d	IC ATTE	9	ERIAL SI POSE OP AT MOIST	
	d A	PLASI LIMIT PCT	16.06	ANGLE/METERIAL SIZE (-)2.0  ANGLE/MEPOSE ANGLE/SLIDE IO IN UROP STEEL PLATE DEGMEES AT B. CHREES AT 3.1 PC1 MOIST 3.1 PCT MOIS	34
	4	Liguid Liwits PCT	18.80	•	
	3	POT VOL CHANSE (-)0.056 IN.SIZE		(-)0.75 IN.SIZE ************************************	40
		POT VOL	0	(-)0.75 I SPECIF GRAVITY	2.84

GRADE RSONNI 1L	TUNNEL SIZE SHAFE SIZE SHAFE BETGIN AULAGE SYSTEM FAIL ASI POCKER CARS 40LB RAIL B IN GAGE 6 OR 8 T MOTORS MACHINE EXCAVATION MACHINE MAKE MODEL	VENTILATION HATER INFLOW UTILITY LINES POWER SYSTEM	GRADE CFM PRESS EXHST SIZE HP GPM AIR WATER PUMP PRIMARY SECONDARY : 7K X 2400 440	SUPPORT SYSTEM	PERSONNEL SUPPLY BOLT-TYPE SIZE ROOF PLATE SET-SIZE-SHAPE SHOTCRETE RAIL 6 FT X 5/8 IN	CUTTERS.HAKE.TYPE.DJAM.CUTTING EDGES RPH TORGUE.HAX/OPERATE THRUST.MAX/OPERAT	WI CENTER INTERIOR GAGE HEAD, CENTER HEAD CENTER
w 7 -	4	VENTILAT	A X			CUTTERS	

21A TUNNEL DATA

KEY

CONVENTIONAL EXCAVATION

GUIDANCE THRUST/SQ FT

POWER SYSTEM

ANCHOR PRESS MUCK SYSTEM

KL8

£

MACHINE JUMBO ATR LEG MACHINES 3IN JACK MARTE FEED LENGTH 6FT

EXPLOSIVES, POWDER FACTOR 7.0 LB/CY TOTAL LAS 140 PRIMERS, 9LB, 60 PCT 1X6 IN TRIM ANFO INTERIOR ANFO CUT ANFO LIFTERS ANFO

GUIDANCE

NUCKING EINCO 21

	-
SHORE MOH SCHMIO.	W
Roc PCT EST	80
COMPR STRNTH KPSI	NA
ORY PCF	4 N
ROCK PROPERTIES METAMOPPHIC: MICA SCHIST OCCASIONAL WURRTZ LAMINATIONS	
IDENTIFICATION NEW YGRK SAMPLE NO NY-1	

KEY 22

PCT (-) NO200	16.0
614. 31N. 21N. 11N. 1/21N. NO4 NOB NOIG NO30 NOSO NOIGO NOZOO	
0 NO100	1.7 7.11
SON OEON	7.5 5.3 7.5 11.7
SCREENS	5.5
H BETWEEN	6.6
NT BY #EIGH I/2in. NO	3.5 21.9 12.3 6.6
PER CEI	3.5 2I.
3IN. 2IP	0
	0
TURE PCT(+)6 IN-SIZE	0
DATA UNIT MOISTURE PCF PCT	1 12.4
UCK DRY C	10

SHAPE OF FRACTIONS SETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC 1=IRREGULAR E=ELONGATEO SP=SPHEROIO

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A-P

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PA

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	Ā
IN FLOW TOUGHNESS INDEX	S12E(-)
FLOW	
AST OEX T	2
LIGOTO PLASTIC SHRINKAGE PL LIMITS LIMIT LIMIT IN PCT PCT	<b>N</b>
PLASTIC LIMIT PCT	**************************************
LIGUIO LIGUIO PCT	• • •
POT VOL CHANGE (-) IN-SIZE	IN.SIZE
POT VOL (-)	II (*)

SIZE(-) IN. ANGLE INTER FPICTION OEGREES AT PCT HOIST
APPARENT BULK COHESION OENSITY PSF AT PCF MOIST
SIZE(-) INPPPAR ANGLE/SLIDE APPAR STEE PLATE COHES OEGREES AT PSF A PCT HOIST P
ANGLE/KEPISE ANGLE/KEPISE 10 IN UKOP DEUKEES AT PCI MOIST
IN.SIZE ************************************

	STEM	SECONDARY 440			ig.	THRUST . HAX ANDERATE	E W W W W W W W W W W W W W W W W W W W		455	GUIDANCE
	POWER SYSTEM	PRIMARY 6600		SMOTCRETE		COPERATE	CENTER KFTL8 KFTL8			MIJCK I MG
	UTILITY LINES	AIR WATER PUNP 4 IN 4 IN 6 IN		SET.SIZE.SHAPE HALF CIRCLE BOLTED STEEL LAGGING IN FAULT ZONES		RPM TORQUE.HAX/OPERATE	HEAD.CENTER HEAD NA KFTLB KFTLB			BLASTING
	MATER INFLOW	100		ROOF PLATE		)GES	GAGE 6 JARVA TCB BISC.OKC-3#	THRUSI/SG FT		*00
		SIZE HP	SUPPORT SYSTEM	HOLT.TYPE SIZE		AKE.TYPE.DIAM.CUTTING EDGÉS	INTERIOR 26 REED+3 DISC OR-3	GUIDANCE THRU LASER KLB		EXPLOSIVES. POWDER FACTOR TOTAL LBS PRIMERS. TRIM INTERIOR CUT
	VENTILATION	CFN PRESS EXHST 36K X		SUPPLY		CUTTERS.WAKE.TYPE	CENTER 2 REED 5 DISC 9K-1	POWER SYSTEM		RCUND. NO. HOLES DEPTH DIAM. CUT.
		GRADE -0.03PCT		PERSONNEL RAIL	ION		7 Z	MUCK SYSTEM BUCKETS TO BELT	CAVATION	RCUND. NO. HO DEPTH DIAM.
KEY 22A TUNNEL DATA	TUNNEL	SIZE SHAPE 11 FT ROUND 6 IN	HAULAGE SYSTEM	MUCK PAIL 17CY CAPS 10T WOTORS 70LB RAIL 36 IN GAGE	HACHINE EXCAVATION	MACHINE	HAKE HODEL JARVA 12-11:	AMCHOR PRESS	CONVENTIONAL EXCAVATION	HACHINE JUMBO MACHINES FEED LENGTH

	. HARONESS	SHORE MOH SCHMIOT			A Z		
	Ī	•					
	ROD	PCT	EST		8		
	COMPR	STRNT	KPSI		٧Z		
	ORY	<u>_</u>	PCF		47		
ROCK PROPERTIES	METAMORPHIC: MICA SCHIST	OCCASIONAL QUARTZ	LAMINATIONS				
IDENTIFICATION	NEW YORK		SAMPLE NO	5-X-2			

KEY 23

PCT (-)	19.0
**************************************	S.
NO100	9
N050	7.
N030	9.1
REENS	5*9
MEEN SCR	9.5
ўНТ 8ЕТ! 104	φ. (S
F BY WEI	10.6
PER CENT	2.2 13.3 10.6 5.0 9.2 6.5 9.1 14.6 9.5
· SIN	
NIE.	0
PCT(+)6 In.SIZE	0
MOISTURE PCT	7.2
WUCK DATA DRY UNIT WT PCF	16
<b>3</b> .	

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATEO SP=SPHEROID

4-P

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IN. STICITY FLOW TOUGHNESS EX INDEX INDEX	
FLOW INDEX	
E(-) IN PLASTICITY INDEX PCI	
LIOUID PLASTIC SHRIMKAGE PLAST LIMITS INDEX PLAST LIMIT LIMIT LIMIT PCT PCT	
PLASTIC LIMIT PCT	
LIGUID	
POT VOL CHANGE (-) IN.SIZE	
.) voi	
2 -	

Z.				TS
S12E(-, IN				
•	BULK	DENSITY	PCF AT	IST PCT MOIST PCT MOIST
	APPARENT	COMESION	PSF AT	PCT MO1S
	/SL 10	PLAT	ES AT	Ci HC
MATERIAL S	ANGLE/HEPOSE	TO IN UROP	DEGREES AT	PCI MOIST
SIZE ***	ANGLE/REPOSE	I IN DROP	DEGREES AT	PCT MOIST PCT MOIST P
IN	PECIF	SPAVITY		

GUIDANCE

MUCKING

BLASTING

ROUNO. NO. HOLES OEPTH OIAM. CUT.

MACHINE JUHBO MACHINES FEED LENGTH

CONVENTIONAL EXCAVATION

	SECONDARY 440	The control of the co			THRUST . HAX/OPERATE	KLB NA	
	POWER SYSTEM PRIMARY SEC. 6600 4		SHOTCRETE		JOPERATE	CENTER KFTLB KFTLB	
	PUMP 4 IN		HAPE E GOLTED ING ONES		TORQUE, MAX/OPERATE	R HEAD KFTLBNA KFTLB	
	AIR WATER PL	<b>e</b> Ne	SET.SIZE.SHAPE HALF C: K-2.E 90LED STEEL LAGGING IN FAULT ZONES		R M	HEAD.CENTER NA	
	GPM SC		ROOF PLATE		Sagr	GAGE 3 JARVA OISC OKC-3M+ TCB	THRUSI/SO FT KLB
	SIZE HP 12 IN 40	SUPPORT SYSTEM	BOLT.TYPE SIZE ROOF PLATE		UIAM+CUITING ED	INTERIOR 12 REED OC-3 TCB BUTTON	GUIOANCE THRU LASER KLB
	PRESS EXHST		SUPPLY		CUTTERS.NAKE.TYPE.UIAH.CUTTING EDGES	CENTER 1 2 REED 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	POWER SYSTEM NA
. 4	GRADE CFM +0.03PCT 18K		PERSONNEL RAIL	20	כטד	14	MUCK SYSTEM BUCKE1S TO BELT
234 TUNNEL DATA THANE!	SIZE SHAPE 8 FT ROUND	HAULAGE SYSTEM	MUCK RAIL 13 CY CARS 10 T MOTORS 70 LR RAIL 36 IN GAGE	MACHINE EXCAVATION	MACHINE	MAKE MODEL Jarva 6-806	AMEHOR PRESS HU

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N. Control of the con

KEY

	PCT (-)	50.9	SP=SPHER01D	184 .			ER IN.
<b>:</b> 5	NO200	1.1	A=ANGULAR S=SUBANGULAR R=אסיואDED P=PLATY C=CUBIC I=IRREGULAR E=ELGNGATED SP=SPHEROID		TOUGHNESS	0.17	SIZE(-)2.0 I ANGLE INTER FRICTION DEGREES AT 9.3 PCT HDIST
SHORE MOH SCHMIDT		10.2	EGULAR E	1	TOUGH	0	IIY AT PCT HDIST
MOH NA	NOSO	8.4 I	C J=1RR	4	FLOW	0	BULK DENSITY PCF AT 0.0 PCT M
SHORE	0 E O O		Y C=CUB]	Id			TSIO
Rob PCT EST 30	SCREENS.	4.9 5.4	O P=PLAT	Id Id	.0S6IN		APPARENT COMESION PSF AT
COMPR STRNIH KPSI 11	BETWEEN SCREENS. NOS NOIG	4.5	R=ROHNDE	Id	SIZE(-) 0.0 PLAST INDEX PCT	0.1	IN
ORY #I PCF	PER CENT HY WEIGHT	13.4	SUBANGULAR	II d	PLASTIC SHRINGE POLYSTICITY PLASTIC SHRINGE INDEX INDEX PCT PCT	22.7	SIZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE · DEGREES AT B.4 PCT MOIST
IIST IICA IE•	PER CENI IIN. I/	17.0	4GULAR S=	<b>a</b>	ATTERBER S L P		L SIZE
DERTIES PHIC: GRAY MICA SCHIST PHIC: GRAY MICA SCHIST PHOL DENSE, FINE TO EXTHEMELY COARSE.	314. 21N. IIN. I/2IN. NO4	0.0 7.6	SCREEN SIZES A=AM	ğ	PLASTIC LIMIT ·	23.3	ANGLE/KEPOSE 10'IN UROP UEGPFES AT 9.8 PCI HOIST
ROCK PROPERTIES METAMORPHIC: GRAY OCCASIONAL GUARAN VARIES FROM DENSE. GPAINED TO EXTREME	, v V V V	0.0			LIQUID LIMITS PCT	24.0	5T
0 × 0 × 0 × 0 × 0 × 0 × 0 × 0 × 0 × 0 ×	E PCT(+)6 IN.S12E	0.0	IONS BETN		32I		ANGL 1 IN
IDENTIFICATION JUEEN LANE SAMPLE NO OL-1	A WOISTURE PCT	0.6	SHAPE OF FRACTIONS BETWEEN		POT VOL CHANGE (-)0.056 IV.SIZE		IN.S12E
EY IDENTIFICA 24 PUEEN LANE SAMPLE NO GL-1	MUCK DATA DRY UNIT	108	SHARS		POT (-)	0	(+) 0.75 SPFCIF GDAVITY

QL-1 CURRENT: 1 SEPT. 1972

		POVER SYSTEM	PRIMARY SECONDARY 4160V 480V		SHOTCRETE
		UTILITY LINES	AIR WATER PUMP 4IN		SET.SIZE.SHAPE OCCASIONAL SEMI- CIRCULAR PLATES PINNED AT SPING LINE AT FAULTS
		WATER INFLOW	H.		AOOF PLATE
			SIZE HP	SUPPORT SYSTEM	BOLT.TYPE SIZE ROOF PLATE
		ITILATION	PRESS EXHST SIZE X 14IN		SUPPLY
		VENT	GRADE CFM +I-3PCT 4K		PERSONNEL Rail
KEY	24A TUNNEL DATA	TUNNEL	SIZE SHAPE IIFT, ROUND	HAULAGE SYSTEM	MUCK

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	THRUST . MAX/OPERA		KLB 377	4)
	TORQUE . MAX/OPERATE	HEAD CENTER	KFTLB KFTLB	
	M da	HEAD CENTER HEAD		
	OGES	GAGE	TAIPLE DISC	
	CUTTERS.MAKE.TYPE.UIAM.CUTTING EDGES	INTERIOR	THIPLE DISC	
	CUTTERS.MAKE.TY	CENTER	TRIPLE 015C	
		<b>⊢</b> 0	TONS	
ACHINE EXCAVATION		MODEL	11-1100	
MACHINE E	HACHINE	MAKE	4 to 1	

-				
THKUST/SO FT		KLB 3.53		
GUIDANCE	LASER			
POWER SYSTEM	4-125HP ELECT.	MUTORS. 40HP	MOTORS.	HYDRAUL IC
MUCK SYSTEM	BUCKET FROM	FACE.	CONVEYOR	BELT TO REAR
ANCHOR PRESS		KLB 3402		

CONVENTIONAL EXCAVATION	ATION	
MACHINE	ROUNO	EXP
JUMBD	NO. HOLES	PO4
MACHINES	DEPTH	TOT
	DIAH.	PRI
	CUT•	TRI
SEED LENGTH		LNI

GUIDANCE

HUCKING

BLASTING

SIZE(-)
ANGLE INTER
FRICTION
DEGREES AT
PCT MOIST

BULK DENSITY PCF AT PCT MOIST

APPAMENT COHESION PSF AT PCT HOIST

ANGLE/KEPOSE ANGLE/SLIDE
10 IN UROP STEEL PLATE
UGGREES AT
PCI MOIST PCT MUIST

FLOW TOUGHNESS INDEX INDEX

IN.....FL PLASTICITY INDEX PCT

PLASTIC SHEINKAGE SIZE(-)
PLASTIC SHEINKAGE IN IN IN IN POPER

LIGUIO LIMITS PCT

IN.SIZE

POT VOL CHANGE (-) IN.S.

B-49

H8-2

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAN S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPMEROID

PCT (-) NO200

61N. 31N. 21N. 11N. 1/21N. NO4 NOS NOS6 NOS0 NOSO NOSO NOSO

PCT (+)6 IN. SIZE

MOISTUPE PCT

MUCK DATA ORY UNIT

SHORE MOH SCHMIOT

PCT

COMPR STRNTH KPS1

P = 5

ROCK PROPLRTIES
SEDIMENTARY, GRAYMACKE
(ARGILLACEOUS QUARTITE)
HASSIVE TO MEDIUM BEDUET)
HIGHLY FOLDED ANJ FRACTURED
NOWMAL OIP OF BEDUING
30 DEGREES TO 45 OEGHEES

IOENTIFICATION MB

KEY 25

SAMPLE NO

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HB-2

M				4		
Ū			UTILITY LINES	AIR WATER PUMP 6 IN 4 IN		SET.SIZE.SHAPE
U			UTILI	AIA NI A		SET+S
Û	ě		WATER INFLOW			PLATE QUIRED
			WATER	GPM		ROOF AS RE
ĵ				30 H	SUPPORT SYSTEM	60LT.FYPE SIZE ROOF PLATE 6 FT X .75 IN AS REQUIRED
u A				PAESS EXHST SIZE HP	SUPPOR	6 FT X
J				EXHST		<b>&gt;</b>
			VENTILATION			SUPPLY
			VEN	F CF		
				GRADE CFM	ļ	PERSONNEL Rail
		•		SHAPE	STEH	ابر <u>ه</u>
The state of the s		KEY 25A TUNNEL DATA		7 E S	HAULAGE SYSTEM	MUCK RAIL 140-200CF BOTTOM DUMPCARS 60-80LB RAIL 101 HOTOR 30 IN GAGE
- ~ .		KEY 25A TUNNE	TUNNEL	S12E 10 FT 10.8 FT	HAULA	RAIL BOTTO 50-80 101 H

POWER SYSTEM PRIMARY SECONDARY 2300 480

SHOTCRETE

THRUST.HAX/OPERAT		8 8 K
ALVOPERATE	CENTER	22
TOBBOT	840	22
M M	HEAO. CENTER	
G EOGE'S	GAGE	
CUTTERS.MAKE.TYPE.DIAM.CUTTING EGGES	INTERIOR	
CUTTERS. MAK	CENTER	
	5	
	HOOEL	
MACHINE	MAKE	

THRUST/SQ FT	KLB
GUIDANCE	
POWER SYSTEM	
HUCK SYSTEM	
CHOR PRESS	
ANCHOR	KL8

CONVENTIONAL EXCAVATION

MUCKING	E I HCO	04					
	IGNITER CORD		DETAPRIME				
ExPLOSIVES.	POWDER FACTOR 7.5LB/CY	TOTAL LBS 210	PRIMERS. IOLB. 70PCT 7/8X8 IN	TRIM ANFO	INTERIOR ANFO	CUT ANFO	TETEDO AND
ROUNO	NO. HOLES 36	DEPTH 8 FT	DIAM. 1 S/BIN	Cut. V			
MACHINE	JUMBO 2 BOOM	MACHINES D-93	ROUNO	I 1/4 STEEL	FEED LENGTH 10FT		

MACHINE EXCAVATION

je po postava po posta	CHMIOT	4 N
HARONESS.	SHORE MOH SCHMIOT	<b>4</b>
	SHORE	19
Rot	Por	8
CUMPR	STRATH	22
ORY	PCF	166
ROCK PPOPERIIES SEOTHENTARY: SANDSTONE FINE	GRAINEO. WELL COMPACTED.	• 1
KEY ICENTIFICATION 26 5-1	SAMPLE NO	<b>1-6</b>

		STATE STATE STATE OF THE STREET STREETS STATE ST	11.8
		0.00	
	<b>₹</b>	, v	0.0 0.0 33.8 20.9 15.5 4.4 2.7 1.3 1.1 3.5 5.0
	92 61 NA NA	4	3.5
	; •		
	26	SCREENS.	7.
κγSΙ	25	BETWEEN	۸ *
PCF	99	WE I GHT	15.5
	<b>106</b>	CENT BY	20.9
5		PER	33.6
VER 50 P			0.0
LIGHT BROWN OVER 50 PCT	00.00		
LIGHT	200	PCT(+)6	0.0
0		ATA MOISTUME PI	4.00
SAMPLE NO	ī	HUCK DATA	5
<b>6</b> 1 (	8	ڮٛۄؙؠ	ac ac

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I-IRREGULAR E=ELONGATED SP=SPHERDID

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Id

Id

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	TER IN.	ji.
TOUGHNESS INDEX 0.28	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT	<b>&amp;</b>
	SULK ENSITY CCF AT MOIST	¥ X
FLOW INDEX S.0	90 PC PC PC PC PC PC PC PC PC PC PC PC PC	
PLASTICITY INDEX PCT	APPARENT COMESION PSF AT PCT MOIST	2
PLASTIC SHPINKAGE PLASTICITY LIMIT LIMIT INDEX PCT PCT PCT 15.50 15.18 1.40	**************************************	88
:	ANGLE/METERIAL ANGLE/MEPOSE ID IN DROP DEGREES AT 6.3 PCT MOIST	56
LIOUIO LIMITS PCT 16.90	ANGLE/REPOSE 1 IN DRAP DEGREES AT 6.3 PCT HOIST	
in.Size	SIZE ANGE ANGE DEGE	, ,
POT VOL CHANGE (-)0.065 IN.SIZE 0	(-)0.75 IN.SIZE ************************************	2.73
	ES 223 II II	

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		TER	SECONDARY 480V		
		POWER SYSTEM	PRIHARY 4160V		SHOTCRETE
		UTILITY LINES	AIS WATER PUNP 21W 41N		SET.SIZE.SHAPE
		WATER INFLOW	6PM S-10		ROOF PLATE 8-2LB CHANNEL. 6IN X 9-SFT OH 13-SFT AT 4FT OR 2FT
			SIZE HP 36IN 7S	SUPPORT SYSTEM	4-5/81N X 4FT
		VENTILATION	CFH PRESS EXHST SI	**	SUPPLY DIESEL TRUCKS, JEEPS
			GRADE C		PERSUNNEL DIESEL TRUCKS. JEEPS
KEY	26A TUNNEL DATA	TUNNEL	SIZE SHAPE IB FT ROUND I IN	HAULAGE SYSTEM	HULK 301N PIGGYBACK CONVEYORS, 361N SUSPENDED CONVEYOR

### MACHINE EXCAVATION

THR ST. HAX/OPERATE		KLB 1580
TORQUE, WAX/OPERATE	HEAD CENTER	KFTL81720 KFTL8
T T	HEAD CENTER HEAD	
EDGES	GAGE 3 ROBBINS.	IZIN STEEL DISC
(E.TYPE.DIAM.CUTTING	INTERIOR	IZIN STEEL DISC
CUTTERS, MAKE,	CENTER I ROBBINS.	
	260	ě
	MODEL 181-122	
MACHINE	MAKE ROBBINS	

THEUST/SQ FT	KLB 3.56
GUIDANCE	
POWER SYSTEM	FOR MEAD
MUCK SYSTEN	FACE, 301N CONVEYOR TO
ANCHOR PRESS	KL8

## CONVENTIONAL EXCAVATION

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TAINTENIOR
cut.
FEED LENGTH

NOCK ING

BLASTING

CF-DE MOH SEMINOT		ž
HARDN		¥
30 33 30		61 NA
000	5	25
COMPR	KPSI	25
ORY T	PCF	991
ROCK PROPERTIES SEDIMENTARY: SANDSTONE FINE COLUMENTARY: COMMANDED.	LIGHT BROWN, OVER 50 P.T	**************************************
KEY IDENTIFICATION 27 7-2	SAMPLE NO	7-1
KEY 27		-

PCT (-)	10.7
6IN. 3IN. 2IN. IIN. I/2IN. NO. NDB NDIG NO30 NO50 NO100 ND200	
MO100	1.5 0.9 33.1 22.6 15.4 4.3 2.6 1.4 1.2 2.5 .3.8
NO50	2.5
W030	1.2
CREENS	9 1.4
ETWEEN S	8
WE 16HT B	5.6 %.
CENT BY I/2IN.	2.6 I
N. IIN.	33.1 2
3IN. 2I	6.0
o IN	2.1
PCT(+)6 IN.SIZE	0.0
MOISTURE PCT	0.4
DATA	06
M O E	

SHAPE OF FRACTIONS BETWEEN SCHEEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID

101.05			ž ,	ুণ্ ম ব্ৰ
	<b>.</b>		INTER INTER ON S AT T HOIS	神经
	TOUGHNESS INDEX	9.78	SIZE(-)2.0 IN ANGLE INTER FRICTION DEGREES AT 2.8 PCT HOIST	
			HOIST	•
And the second	FLOW	96.9	APPARENT BULK COMESION BULK FSF AT PCF AT 2.8 PCT MOIST 0.0 PCT MOIST	95.8
to the second			F01ST	肾
<b>₹</b>	ASTIC SHRINKAGE PLASTICITY HIT LIMIT PCT HIT PCT	5.37	APPARENT COMESION PSF AT 2.8 PCT	•
<b>1</b>	-> 3ZIS:		IST IS	
	RG LIMITS. SHRINKAGE LIMIT	17.58	L SIZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGHEES AT T 2.6 PCT MOIST	&
Id ,	TTERRE		21:	
i i	PLASTIC LIMIT PCT	17.63	ANGLE MATERIAL S ANGLE MEPOSE 10 IN URUP UEGAFES AL 2.6 PCI MOIST	31
<b>z</b> "			2.5	
<u>*</u>	LIOUID	23.0	AREPUSE DROP ES AT CT MOIST	No.
E. 27	IZE		ANGLE ANGLE DEGRE	2
	HANGE IN.S.		4.S1ZE	5,
	POT VOL CHANGE (-)0.056 IN-SIZE	0	GRAVITY DEGREES AT 2.6 PCT 401ST	<b>69.</b>
	, A 1			# 14

1 SEPT. 1972

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	5
KEY	27A TUNN

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	ONDARY 480V		
	PRIMARY SECONDARY		SHOTCRETE
UTILITY I INFO	AIR WATER PUMP		SET.S1ZE.SHAPE
WATER INFLOW	6PN 5-10		ROOF PLATE 8-2LB CHANNEL 6IN X 9-5FT OR 13-5FT AT 4FT
	36IN 75	SUPPORT SYSTEM	HOLTOTYPE SIZE
VENTILATION	CFH PRESS EXHST		SUPPLY DIESEL TRUCKS, JEEPS
	GRAPE +2.0PCT		PERSONNEL DIESEL TRUCKS JEEPS
TUNNEL	SIZE SHAPE IBFT ROUND	HAULAGE SYSTEM	MUCK 30IN P.GGYBACK CONYEYOP. 36IN SISPENDED CONVETOR

#### MACHINE EXCAVATION

THRUS; . MAX/OPERATE	Tropy	KLB 1580 KLB 747
TOHQUE, MAX/OPERATE	HEAD CENTER	KFTLB KFTLB
RPR	HEAD CENTER HEAD	
CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	CENTER INTERIOR GAGE I ROBBINS 7.5IN 41 ROBBINSIZIN ROBBINS 12 IN	TRIPLE STEEL STEEL DISC DISC
	22 260	100
	HODEL NS 181-122	
MACHINE	POBBINS	

THRUST/SO FT	KLB 2.91
GUIDANCE	LASER
POWER SYSTEM	FOR HEAD
HUCK SYSTEM	FACE - 30 IN CONVEYOR TO PEAR
PRESS	
ANCHOR PRESS	RL6

# CONVENTIONAL EXCAVATION

BLAST	
EXPLOSIVES. POWDER FACTOR TOTAL LBS	INTERIOR
ROUND. NO. HOLES OEPTH	cuT•
HACHINE JUMBO HACHINES	FEED LENGTH

		PCT (-)	8.0	S=SUBANGULAR R=ROUNDED P&PLATY C&CUBIC I*IRREGULAR E*ELONGATEO SP=SPHEROII		O IN. TER AT MOIST	
<b>10</b>		NO200	6.0	=ELONGATEO	TOUGHNESS INOEX 0.26	SIZE(-)2.0 ANGLE INTER FRICTION DEGREES AT	9
SS	2	NO100		Z Z	TOUGH	24	
SHORE NON SCHMIOT	<b>4</b>	NO50	7	I = I RREGL	E X	BULK BULK PCF AT 0.0 PCT MOIST	100
SHORE	PARALLEL 41-55. Normal 41-54.	NO30	:	C=CUBIC	FLOW		
PCT EST	0	REENS.	2.0	æPLATY	6IN.	APPARENT COHESION PSF AT HOIST	850
COMPR STRNTH KPSI	4 MAJOR BEOS 22 TO 29. 3 MINOR BEDS IZ TO 17. MT. AVE 23	314. 21N. 1IN. 1/21N. NO4 NOB NOI6	7 3.5	-ROUNDED P	ASTIC SHINTS.SIZE(-) 0.056IN ASTIC SHINKAGE PLASTICITY HIT LIMIT INDEX T PCT A.81 IA.51 0.79	°	
	* 2	16H7 B	5.7	# AR R	5512	IN IDE AT HOIST	, , L'
DRY PCF	152	INT BY WEIGH	16.4	i=SUBANGL A	RG LIMIT SHYNKAG LIMIT PCT I4.5I	SIZE:-)2.0 IN ANGLE/SLIDE SIEL PLATE OEGREES AT 1.0 PCT HOIST	59
E TO	ا پ	PER CEI	4 I4.9	A=ANGULAK PA PA	ITERBE	512E	
MASSIV ITERBEO ILIMEST	GRAIN SIZE FINE TO BUAHTZ 24 TO 33 PCT.	21N.	3 14.4		PLASTIC LIMIT PCT 14.81	ANGLE/MEPOSE ANGLE/MEPOSE OEGREES AT OF PCI MOIST	
HALE. FU. IN SHALE.	24 10		6 11.3	S12ES	PLA PCT 16.	ANGLE/MEPO IO IN UROP OEGREES AT	<b>S</b> 2
ROCK PDOPERTIES SEDIMENTARY: SHALE, MASSIVE TO THINLY LAHINATED. INTERBEDGEO SILTSTONE AND SHALE, WITH MINDR SANDSTONE AND LIMESTONE	GRAIN GUAHIZ	NI 9	12.6	SCREEN SIZES	ouro TITS 115		
ROCK P SEDIME THINLY SILTST	COAPSE	PCT(+)6 IN-SIZE		SET WEEN	LIS.	5 - 5	
			7.8	IONS &	321		25
FICATION NO		MOISTURE PCT	1.1	SHAPE OF FRACTIONS BETWEEN	POT VOL CHANGE (-)0.056 IN.SIZE 0	IN.SIZE	
IDENTIF II-3 SAMPLE II-3		MUCK DATA DRY UNIT	66	SHAPE (	POT VOL. (-) 0.056	(-)0.75 IN.SIZE SPECIF GRAVITY	2.65
χ 90 70,		¥ 0 3					

	DATA
KEY	28A TUNNEL

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,	POWER SYSTEM	PRIMARY SECONDARY		SHOTCRETE
	UTILITY LINES	AIR WATER PUMP 4IN 4IN 4IN		SET.SIZE.SHAPE
	MATER INFLOW	GPM		ROOF PLATE 1111N X 10FT
		ENIST SIZE HP	SUPPORT SYSTEM	BOLT.TYPE SIZE ROOF PLATE 5/BIN X 6FT IIIN X 10FT 4FI X 4FT PATTERN
	WENT ILATION	C/H PRESS EXHST		SUPPLY OTESEL TRUCKS.
		SHADE		PESSONGL DIESEL HWCKS.
	TUNNET.	STEE ACT	NAULAGE SYSTEM	MACK MASSAGE 51-5 SCOOPTRANS, 1610s SHATLE

#### MACHINE EXCAVATION

B-56

HRUST . HAX/OPERATE	17 red	
TORQUE . MAX/OPERATE	CENTER	KFTEB KFTEB
TOROUE.	HEAD	KFTLB KFTLB
A G	HEAD, CENTER	
NG EDGE'S	GAGE	
IKE.TYPE.DIAM.CUTTING EDGES	INTERIOR	
CUTTERS, MAK	CENTER	
	3	
	HODEL	
MACHINE	HAKE	

ANCHOR PRESS HUCK SYSTEM POWER SYSTEM GUIDANCE THRUST/SQ FT

### CONVENTIONAL EXCAVATION

NCC SCOO	
BLASTING ELECTRICAL M.S. DELAYS	
EXPLOSIVES, POWDER FACTOR 3.5LB/CY TOTAL LBS 234 PAINFRS, 16LB 1.25IN X BIN, 75PCT TEIM THE RISH 1.25IN X BIN, 75PCT	INTERIOR ANFO CUT LIFTERS 32LB 1.25IN X 12IN. RXL 60PCT
ROUND. NO. MOLES 35 DEPTH 10.5FT - 11CT DIAM. 1-374IN CUT. V	1-6FT BUSTER HOLE SF./HOLE 5.1
MACHINE JUMBO 2 BOOM HYDROJIB MACHINES 2-AR93 ORIFTERS	FEED LENGTH 14FT

11-3

	**	PCT (-) ND200	E.3	#SPHEROID;	dr.	IN.	
101	4	00 NO200	0.2	S=5UBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGUL/R.E=ELONGATED SP=SPHEROID PA FA 'PA A A	TOUGHNESS INDEX 0.05	SIZE(-)2.0 I ANGLE INTER FRICTION DEGREES AT 0.2 PCT MOIST	4
HOH SCHMIDT	2	NOS0 ND100	2.0	I RREGUL/R.		AT PCT MOIST	001
SHORE	PARALLEL 41-55. NDRHAL 41-54.	ND30 NO	•	A A	FLDW INDEX	BELL DENS	
ROD FST	8	SCREENS	5 1.2	Paplaty (	056IN. TICITY X	APPARENT COHESION PSF AT 0.2 PCT MOIST	282
COMPR STRNIH KRSI	4 MAJOR WEDS 22 TD 29. 3 HINDR BEDS 12 TD 17. NT. AVE 22.	BETWEEN ND8	3.4 2.5	REROUNDED	IZE(-) 0.00 PLAST IMDEX PCT 0.20	Z +	7
DRY PCF	991	ENT BY WEIGHT 1/2IN. MD4	12.7	S=SUBANGULAR PA	ERG LIMITS.cs SHRINKAGE LIMIT PCT 13.26	SIZE(-)2.0 IN AMGLE/SLIDE STEEL PLATE DEGREES AT 0.9 PCT MUIST	<b>82</b>
MASSIVE TO INTERSEDDED	UNE AND LIMESTONE LAVERS SIZE FINE TO COARSE, 24 TO 33 PCT.	ZIN. IIN.	7.0 19.3 15.7	A=AvGULAR PA PA	PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT 18.60 13.26 0.20	**************************************	62
PERTIES ARY: SHALE AMINATED. II	IE AND LIMES 2E FINE TO 14 TO 33 PC1	61N. 3IN.	17.7 17.0	SCREEN SIZES	a yı		
RDCK PRO SEDIMENT THINLY L	SANDSTON GRAIN SI GUARTZ 2	PCT(+)6 IN.S17E	8.2	IS GETWEEN	LIOUI LIMIT PCT IS-80	ANGLEZEPOSE I IN DROP DEGREES AT	<b>35</b>
ICATION		HDISTURE PCT.	1.1	SHAPE DF FRACTIONS DETWEEN	CHANGE IN-SIZE		
- E - 9	<b>7-</b>	MUCK DATA DRY UNIT #T PCF	96	SHAPE D	PDT VDL (-)0.056	(-)0.75 IN.SIZE Specif Galvity	2.79

		POWER SYSTEM	PRIMARY SECONOARY 4160V 609V		ETE
		0d			SHOTCRETE
		UTILITY LINES	AIR MATER PUKP		SET.SIZE.SHAPE
		WATER INFLOW	OPH		ROOF PLATE
			SIZE HP	SUPPORT SYSTEM	5/8IN X 6FT AT 4FT X 4FT
		TILATION	PRESS EXHST S. ENTRY FACE	<b>T</b>	SUPPLY 601 DIESEL 5/1 TRUCK 4F
		VENTI	GRADE C5H 0.0 20K		PERSONNEL OIESEL TRUCK
KEY	29A TUNNEL DATA	TUNNEL	JZE SHAPE ISFTXB RECT	HAULAGE SYSTEM	MUCK OIESEL SHUTTLE CAR, CONVEYOR

0

	THRUST . MAX/OPERATE		KLB 1,093	
	TORQUE. MAX/CPERATE	CENTER	KFTLB KFTLB	
	TORQUE . MA	HEAD	KFTLB KFTLB	
	Hda	HEAD CENTER HEAD	1 S-8LOWER	
	CUTTERS.HAKE.TYPE.UIAM.CUTTING EGGES	CENTER INTERIOR GAGE	HEADS	
			L.T.	
CAVATION		MODEL		
MACHINE EXCAVATION	KACHINE	MAKE	COPCO	

THRUST/SQ FT	KLB
GUIDANCE	LASER
POWER SYSTEM	HEAD HOTATION 2-78K# MOTORS HYORAULICS
MUCK SYS'EN FLIGHT CONVEYOR	STAR WHEEL+ HE
ANCHOR PRESS	KLB 1000

	EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS, TRIM INTERIOR CUT	
VATION	ROUND. NO. HOLES DEPTH DIAM. CUT.	
CONVENTIONAL EXCAVATION	MACHINE JUMBO MACHINES FEED LENGTH	

	\	Ĵ.	,		301
		PCT (-) ND200	5.9	9	SPHE
		•		DRYIN	ED SP
		ND20		FORE	PNGAT
TOT			9-0	D BE	EFEL
SCH		NOIO	I.2	REENE	JLAR
ARDNE DH		9	I.2	S.	IRREGI
ÌĬ	•	Š.	S.	LINE	C I=1
SHDRE HOH SCHWIDT	CC-1+	**************************************	0.0 % 24 23 20 7.3 4.5 I.1 1.5	INE. DKY SCREENED (ASTM C134). AFTER WASHING (ASTM C117). LOWER LINE. SCREENED BEFORE DRYING	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R±.40UNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROI
Port EST	•	ENS.	1.1	1373.	LATY
	6	SCREE	8.	STN CI	E0 Pæ
COMPR STRNTH KPSI	8	NDB		¥ 91	OUND
QNA .	•	1 BE1	7.3	ASHIN	- E
PCF 25		F 16H		FER #	<b>IGULA</b>
270	<u>.</u>	AY .	NN	. AF	SUBAR
		CENT 1/	31.0	CI36)	IR SE
		IIN	80	STH	NGUL
ON E		Z Z	2 2	En C	A=A
SEDIMENTARY: SHALE INTERNETOR SILTSTONE SHALE MINOR SANDSTONE LIMESTONE FINE TD COUSE: CALADALA		Z	4 2	CREEN	SIZES
SILT SILT SILT SILT SILT SILT SILT SILT		۳ - خ	•	S ¥ S	re en
STORES				NE.	N SC
SHAL SHAL LINE		PCT(+)6 IN.SIZE		ER L1	ETWEE
ž 05 ⊶ + C	•	IN.	0.0	dan.	NS BI
Š		MOISTURE PCT		SIS	ACTID
10ENTIFICATION 72-1 SAMPLE ND 72-1			1.5	SCREEN ANALYSIS: UPPER LI	DF FR
IDENTIFICA 72-I SAMPLE ND 72-I		WUCK DATA DAY UNIT WT PCF		PEEN	TAPE
27 0 72 A 2 5 7 5 7 5 7 5 7 5 7 5 7 5 7 5 7 5 7 5		OKY WT	36	SC	ý
u m		-			

* *		IN. T OIST	na. 325
TOUGHNESS	0.20	SIZE(-)2.0 IN ANGLE INTER FRICTION DEGMEES AT I.O PCT HOIST	
FLOW INDEX	0,**	BULK DENSITY PCF AT	100
PLASTICITY INDEX PCI	07.0	APPARENT BULK CDHESIDN DENSITY PSF AT PCF AT I.0 PCT MOIST 0.0 PCT MDIST	170
PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT	15.58	IZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT I.3 PCT MOIST	30
PLASTIC LIMIT PCT	17.10	ANGLE/MEPOSE ANGLE/SI 10 IN URDP STEEL PI UEUPEES AT DEGREES 1.3 PCI MDIST 1.3 PCT	35
E LIGUID LIMITS PCT	18.00	NALLAFPOSE IN Duck FORETS AT 3 PCT HOIST	36
POT VDL CHANGE (-)0.055 IN.SIZE	0	(*)0.75 IN.SIE . SPECIF GRAVITY	2.72

CURRENT: I SEPT. 1972

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	ES POWER SYSTEM	PUMP PRIMARY SECGNOARY 4IN 4160 480		IAPE SHOTCRETE
	UTILITY LINES	AIR WATER PUMP 2 IN 4IN		SET.SIZE.SHAPE
	MATER INFLOW	GPM 5-10		ROOF PLATE 8.2 LB CHANNEL 6 IN X9.SFT OR 13.5 FT AT 2 FT
		SIZE HP 36 IN 126	SUPPORT SYSTEM	G-6FTX5/8 IN
	ILATION	PRESS EXMST SIZE HP		SUPPLY DIESEL . TRUCKS JEEPS
	VENT 1	GRADE CFM +10.0PCT 18K		PERSONNEL O1ESEL TRUCKS JEEPS
UNNEL DATA	UNNEL	SIZC SHAPE IN ROUND I IN	AULAGE SYSTEM	JUCK 30 IN PIGGYBACK CONVEYOR 36 IN SUSENOED

	THRUST . HAX/OPERATE		KLB 769	
	JOPERATE	CENTER	KFTLB KFTLB	
	TORQUE. MAX/OPERATE	HEAO	KFTLB1147 KFTLB KFTLB KFTLB	
	RPM	HEAD CENTER HEAD	<b>.</b>	
	CUTTERS.MAKE.TYPE.UIAM.CUTTING EGGES	CENTER INTERIOR GAGE	7.SIN TRIPLE W/ 121N ESCO RING 121N W/ESCO RIN G	
		130		
101		MODEL	221-101	
FACHINE EXCEPT 100	MACHINE	MAKE	SN GBOX	

THRUST/SQ FT	KLB
GUIDANCE	LASER
POWER SYSTEM	4-200 HP FOR HEAD
MUCK SYSTEM	BUCKETS TO BELT
ANCHOR PRESS	KLB 1000

CCAVENTIONAL EXCAVATION	SAVATION				
MACHINE JURGO MACHINES	ROUNO. NO. MOLES DEPTH OIAM.	EXPLOSIVES, POWOER FACTOR TOTAL LRS PRIMERS,	BLASTING	MUCKING	GUIDA
FEED LENGTH		INTERIOR CUT			

	PCT (-) NO200	<b>0.</b>	P=SPHERO10				ITER IN.		45
NA NA	NO100 NO250	•	A=ANGULAR S=SUBANGULAR R=ROUNDEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROIO		TOUGHNESS	0.32	SIZE(-)2. ANGLE IN FRICTION DEGREES 0.3 PCT	9	1.5EPJ. 1972
SHORE MON SCHIIOT	NO50	1.0	UBIC I=IRREGU	۲ ۲	FLOW	3.20	BULK BULK BENSITY PCF AT 0.0 PCT MOIST		CURRENT:
85 EST 65	SCREENS	3.0 2.0	EO P=PLATY C=C	٠ ٧	A.ASTICITY MOEX	2	APARENT COMESION PSF AI 0.3 PCT MOIST	410	I-OSH
CAPR 41 STRNTH PCF KPSI 71 NA	21N. 11N. 1/21N. NO. NOB NOIG NOSO 1	16.0 4.0	ANGULAR R <del>e</del> round	4	MITS.ASTEE+	1.03	(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT	27	
ν ω 2 ω	PER CENT HY	.24.0 18.0 I	EANGULAR S=SUB	<	LASTIC THEMBERG LE	1.01	IAL SIZE SE IST 0		
ROCK PAOPERTIES SEDTHENTARY: CONGLOMERATE (RRFCCIA) .25 IN TO 10 IN ADUNCED TO ANGULAR BOULDERS CONGLES, PEBLES, PREDOMINATELY LIMESTONE MATPILS, W/CHER'S SCHIST, DIRASE FRAGMENTS	2	17.0 12.0 '	LEN SIZES	4	2 7 6	12.77	ANGLEYKE 10 IN UP DEGREES 0.4 PCI	62	
ROCK PROPERTIES SEDIMENTARY: COI (RRECCIA) .25 IN ADUNDED TO ANGUL COMBLES, PEBBLE! PREDOMINATELY L MATPIX: WCHERY L DIRASE FRAGMENT	PCT(+)6 IN.SIZE 6IN	•	SHAPE OF FRACTIONS BETWEEN SCR		LINID PCT	13.80	ANGLE/REPOSE I IN L-20P DEGREES AT	en E	
IDENTIFICATION MSU Sample MSU-1	TA IT MOISTURE F PCT	δ. 6	PE OF FRACTIO		POT VOL CHANGE (-)0.036 IN.SIZE		(-)0.75 IN.SIZE SPECIF GRAVITY	ž	
KEY IDENTIL 31 HSU SAMPLE HSU-1	MUCK DATA DBY UNIT	104	SH		P0T		SPE GRA	2.74	

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		ATAC
(EY	314	UNNE
	KEY	318

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STFR	PRIMARY SECONDARY 4168 480	¥.	
POWER SYSTEM	PRIMARY 4168		SHOTCRETE
UTILITY LINES	AIR MATER PUMP 6 IN 2 IN.	ť	SET.SIZE.SHAPE
WATER INFLOW	GPM		ROCF PLATE 3FT-4,FT-6FT 6 PLATES/SFT SPAN
	PRESS EXHST SIZE HP X 24 IN SO	SUPPORT SYSTEM	BOLT. TYPE SIZE REFIX S FI S S IN S S IN S S IN S S IN S S IN S S IN S S IN S S IN S I
VENTILATION	CFM PRESS EXHS		SUPPLY
	GRADE 0.0		FERSONNEL RAIL
_	SHAPE RECT	HAULAGE SYSTEM	MUCK RAIL 44CF ROCKERCARS 4-6T MOTORS 18 TA CARE
TUNNEL	512E 9 FT 10 FT	HAULAG	A CE LES TE LES

#### MACHINE EXCAVATION

B-62

THRUST. MAX/OPERATE		KL8 KL8		4
TORQUE. HAX/OPERATE	CENTER	KFTLB :		
TORQUE. H	HEAD	KFTLB KFTLB		
A T	HEAD, CENTER HEAD			
NG EÓGES	GAGE		GUIDANCE THRUST/SQ FT	WLB
E.DIAM.CUTTI	INTERIOR.		GUIDANCE	
CUTTERS.MAKE.TYPE.DIAM.CUTTING EÓGES	CENTER		POWER SYSTEM	
	Ė		ANCHOR PRESS MUCK SYSTEM	
	MODEL		PRESS MUC	
MACHINE	MAKE	ij	ANCHOR P	KL8

### CONVENTIONAL EXCAVATION

KOUND. NO. MOLES 42-50 DEPTH S.5 FT OIAM. 1 3/8 IN	•
MACHINE JUMPO 3 BOOM MACHINES 3IN DIA ORIFTER	FEED LENGTH 7FT

		•					
<b>&gt;</b>		o Z					
LB/		GEL					
POWDER FACTOR 8.2 LB/CY		LB AMOGEL NO.	1	INTERIOR CARBANITE		ITE	
104	150	5 68	4ITE	ARBA	31	CARBAMITE	
FAC	88	. 2	ROA	S S	CARBINITE	CAS	
POWDER FACT	1	PKINERS. 25	TRIN CARBANITE	ERI	3	LIFTERS	
0	15	PKI	TRI	IX.	55	LIF	

\*

32 MSU 32 MSU SAMPLE NO MSU-2	ROCK PROPERTIES SEDIMENTARY: CONGLOMERATE 11/4 - 10 IN ROUNDE') TO ANGULAR ROULDEMS. COBBLES. PEBBLES IN PREDOMINATELY LINESTONE MATRIX. W/CHENTY SCHIST TO MODERATELY CONSOLIDATED	DRY PCF	COMPR STRNTH KPS1	R0D PC1	SHORE MOH
F 5.0	NO.	N	ON ROCK PROPERTIES  SEDIMENTARY: CONGLOMERATE  174 — 10 IN ROUNDED TO ANGULAR  GOULDEMS. COBBLES, PEBBLES  IN PREDOMINATELY LINESTONE  MATRIX. W/CHENT. SCHIST  DIABASE FRAGMENTS WELL  TO WOOFHATELY CONSULATED	ON ROCK PROPERTIES  SEDIMENTARY: CONGLOMERATE  174 - 10 IN ROUNDE') TO ANGULAR  ACULOEMS. COBBLES. PEBBLES  IN PREDOMINATELY LIMESTONE  MATRIX: W/CHEATS SCHIST  DIABASE FRACHENTS WELL  TO MODEWATELY CONSCIONATED	ON ROCK PROPERTIES  SEDIMENTARY: CONGLOMERATE  174 - 10 IN ROUNDED TO ANGULAR  ROULOEMS: COBBLES+ PEBBLES  IN PREDOMINATELY LINESTONE  MATPRIX: W/CHENT: SCHIST  DIABASE FRAGMENTS WELL  TO MODERATELY CONSULATED

	PCT (-)	1.0
*,	1,0200	
	NOIDO	۰
	NOSO	٥
	N030	0
	SCREENS.	7.0 7.0
	T BETWEEN	I.5
	HY WEIGH	5.1
ŀ	**************************************	28.9 17.2 16.0 10.4 5.1 1.5 0.7 0.7
	IN. 2IN.	17.2 16
	6IN. 3	6.82
	PCT(+)6 IN-S1ZE	1.91
	PCT	1.9
	MUCK DATA	107
	-	

SMAPE OF FRACTIONS BETWEEN SCREEN SIZES A\*ANGULAR S=SUBANGULAR R=ROUNDED P=PLAI C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID

FLOW TOUGHNESS INDEX INDEX
FLOS
IZE(-) PLASTICITY INDEX PCT
LINITS LIMIT LIMITS.SIZE(-) IN SHRINKAGE PLASTICITY IMITS LIMIT LIMIT INDEX PCT PCT
PLASTIC LIMIT PCT
LIOUIO LIMITS PCT
POT VOL CHANGE (-) IN.SIZE

N TS
SIZE(-) ANGLE INTER FRICTION OEGREES AT PCT MOIST
IN APPARENT BULK COHESION OENSITY PSF AT PCF AT ST PCT HOIST
ZSLIOE PLATE ES AT
ANGLE/MEPOSE 10 IN UROP OEGREES AT
IN.SIZE ************************************
SPECIF GRAVITY

	DATA
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TEH	PRIMARY SECONDARY 4160 480		
POWER SYSTEM	PRIMARY 4160		SHOTCRETE
UTILITY LINES	AIR MATER PLANTS	ř.	SET+SIZE+SHAPE
WATER INFLOW	GPM		ROOF FLATE 3.4 1/2.6 FT 7 PLATES I SPAH
		SUPPORT SYSTEM	BOLT-TYPE SIZE OF FT X 5/8 IN 21 BOLTS/5 FT SPAN
ITILATION	PRESS EXHST SIZE MP X 24 IN 50		SUPPLY
VENI	GRADE CFM		PERSONNEL RAIL
TUNNEL	SIZE SHAPE 9FT I RECT 0 FT	HAULAGE SYSTEM	MUCK PAIL CACF HOCKER DUMP 4-61 HDTOR 30LB RAIL 18 IN GAGE

MACHINE EXCAVATION

OPERATE				
THRUST. HAX/OPERAT		KLB	KL8	
TOROUE . MAX/DPERATE	CENTER	KFTLB	KFTLB	
TOROUE. H	HEAD	KFTLB	KFTLB	
MPM	HEAD CENTER HEAD			
G EDGES	GAGE			
UTTERS, MAKE, TYPE, UIAM, CUTTING EDGES	INTERIOR			
CUTTERSOMAKE	CENTER			
	13			
	MODEL			
MACHINE	MAKE			

GUIDANCE THRUST/SQ FT PDWER SYSTEM ANCHOR PRESS MUCK SYSTEM

KL8

CONVENTIONAL EXCAVATION

ROUND.	NO. HOLES 50 OEPTH 5.5 FT	DIAM. I 3/8 IN	-
		,	
	SIN DIA	4	TH 6FT
HACHINE	JUMPD 2		FEED LENGTH

EXALDSIVES, POWDER FACTOR 6.7 TOTAL LBS 122 PRIMERS, AMOGEL TRIM INTERIDA AMOGEL DR CARBAHITE CUT

GUIDANCE

MSU-2

	As ,	PCT (-) ND200	6.7	>=SPHEROIC			
TOI	<b>4</b>	NO FOO NO SOO	<b>8</b>	A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC J=IRREGULAR E=ELONGATED SP=SPHEROIC		TOUGHNESS	50.0
SHORE MOH SCHALOT	¥.	NOSO ND	1.8	*IRREGULAR			R
SHORE	\$	ND30	2.0	C=CUBIC I		FLOW	4.0
R00 PCT EST	100	SCPFENS	6.5	ED PEPLATY	14 1	) 0.185IN PLASTICITY INDEX PCT	
COMPR STRNTH KPSI	6	T BETWEEN	**	AR REROUND	- I	SIZE(=) 0 PLA INDI PCT	5.0
DRY CF	9	21N. IIN. I/21N. NO4 ND6 ND16	1.55.0	S=SUBANGUL,	ā	PLASIC SHRINKAGE PLASTICITY PLASIC LIMIT LIMIT LIMIT PCT	9.6
LIGHT AINED, ACES TO	<u>s</u>	N. IIN.	25.0 18.0	A=ANGULAR	I d	T.C. ATERB	
ROCK PROPERTIES SEDIMENTARY: LIMESTONE LIGHT TO MEDIUM GRAY FINE GRAINED, SOME CHERT NOOVLES, TRACES-TO	OCCASIONAL CLAT PARITNES	3IN.	0.0 3.0	SCHEEN SIZES	PAI	PLASTIC LIMIT PCT	12.3
SEDIMENTARY LISTOME CHERT GRAY	CASIONAL C	•)6 •	•			LIGUID	12.5
	6	TURE PCT(*)6		ACTIONS BE		46E	
IDENTIFICATION LAWRENCE SAMPLE NO	2-4	DATA WOISTURE PCF PCT	7.2	SHAPE OF FRACTIONS BETREEN		POT VOL CHANGE (-)0.065 IN.SIZE	
33 LA	3	MUCK DATA DRY UNIT	26	·		4.0	

	SIZE(-)2.0 IN. AMSLE INTER FRICTION OEGREES AT	
	TA TO	
٠,	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2
	212 8 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	7 7
		15
	BULK BULK DENSITY PCF AT HOIST PCT MOIST	
	¥ + 5	Z Z
	POEL	75.
	TSI	
	N	-
	PAKE HESI PC	-
	488	
		F.
	IN DE TE OIST	*
	PLA FES A	31
	INGLE NAGLE STEEL	
	SIZE	
	ANGLE/KEPOSE ANGLE/SLIDE APPAKENT BULK 10.IN UROP STEEL PLATE COMESION DENSITY DEGREES AT OEGREES AT PSF AT PCF HOIST PCT HOIST PCT HOIST PCT HOIST	Ŋ.
	CHERT PORTE	
	FORE PPE	38
	Sons	
	5	
	PPOSE OP AT MOIS	÷
	FEES PCT	ø
	ANG 1 I DEG	
	3215	
	Z	
	SPECIF ANGLE/REPUSE SPECIF ANGLE/REPUSE GRAVITY DEGREES AT 5.4 PCT MUIST	.83
	SPEC GRAV	2.83

	POWER SYSTEM	PRIMARY SECONDARY 4166V 480V	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	SHOTCRETE	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	PERATE THRUST . MAX/OPERATE	CENTER KFTLB KFTLB KFTLB			MUCKING GUIDANGE
	UTILITY LINES	AIR WATER PUMP 6IN 2IN 6IN	er 42 - 4 9.7	SET. S1 ZE. SHAPE 5		RPM TOROL . HAX/OPERATE	HEAD.CENTER HEAD 9 30 KFTLB KFTLB206			BLASTING
· · · · · · · · · · · · · · · · · · ·	WATER INFLOW	6PN 40-12		AOOF PLATE		95	GAGE STANFINGE TCB ISIN ROLLER	THRUST/SQ FT		<b>20</b>
		SIZE 14P	SUPPORT SYSTEM	NONE SIZE	* 4	MAKE. TYPE. DIAM. CUTTING EDGES	INTERIOR IL LAWRENCE TCB ISIN OISC. II-TCB ISIN	GUIOANCE THRU LASER KLB		EXPLOSIVES. POWDER FACTOR TOTAL LBS. PRIMERS. TRIN INTERIOR CUT
	VENTILATION	CFH PRESS EXHST		SUPPLY		CUTTERS.MAKE.TYPE	CENTER I LAWRENCE TCB 24IN TRICONE	ũ W I O ~		ROUNO. NO. HOLES OEPTH DIAM. CUT.
		GRADE +0,25PCT		PERSONNEL RAIL	VATION		HORDEL MT HARDROCK 400 TONS	S HUCK SYSTEM BUCKETS FROM FACE. 24 IN CONVEYOR ID REAR	EACHARITON.	NO NO OEF
KEY 334 TUNNEL OATA	TUNNEL	SIZE SHAPE 13FT, ROUND 8IN	HAULAGE SYSTEM	MUCK RAIL	MACHINE EXCAVATION	MACHINE	MAKE H ALKIRK H	ANCHOR PRESS	CONVENITORAL EXCHANGED	MACHINE JUNBO HACHINES * FEED LENGTH

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÷	PCT (+) NO200	P=SPHER010				OF THE TATE TO THE THE THE THE THE THE THE THE THE THE	
M H 100	0100 NOE00	A=ANGULAR S=5UBANGULAR R=ROUNOEO P=PLATY C=CUBIC I*IRREGULAR E=ELONGATED SP=SPHEROID	e,	TOUGHNESS INDEX	0.41	SIZE(-)2.0 ANGLE INTER FRICTION DESREES AT 7 PCT HOL	<b>X</b>
HARONESS	NO50 NO100	:IRREGULAR				SITY AT PCT MOIST	, <b>4</b>
SHORE 46	NO30 NO	-I 21862=2	-[1	FLOW	2.9	BULK OENS PCF	ė,
R00 PC1 ES1	SCREENS	O PEPLATY		•		APPARENT COMESION PSF AT PCT MOLST	<b>1</b>
COMPR STRNIH KPSI	BETWEEN NOB	R R#ROUNDE		SIZE(-) 0.18 PLASTI INDEX PCT	1.2	IN	
160 PCF	21N. IIN. 1/21N. NO. 25.9 19.6 20.2	:=SUBANGULA	PAL	PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT	10.0	SIZE(-)2.0 ANGLE/SLIDE SIEEL PLATE OEGREES AT M.4 PCT MOI'	<b>®</b>
LIGHT AINEO.	PER CCN1	=ANGULAR S	PAI PI	ATTERBE			
ROCK PROPERTIES SEDIMENTARY: LIMESTONE LIGHT SOUR GRAY: FINE GRAINEO. SOUR CHERT NODULES. TRACES TO OCCASIONAL CLAY PARTINGS.	31N.	CREEN SIZES A	PAI	PLAST LINIT PCT	10.6	ANGLE, HEPOSE 10 IN JROP 0EGREES AT	•
ROCK PROPERTIES SEDIMENTARY: LI MEDIUM ROAYY SOME CHERT NOOU OCCASIONAL CLAY	) 6	WEEN SCREE		LIGUIO LIMITS PCT	11.8	EPOSE OP AT HOIST	\$1
	URE PCT(+)6 IA.SIZE 0.0	CTIONS BET		1ANGE IN.SIZE		ANGLE/REPOSE IN OROP OEGFEES AT 6-1 PCT HOIS	7
IDENTIFICATION I AWRENCE SAMPLE NO LAW-3	DATA . UNIT MOISTURE PCF PCI 5.55	SHAPE OF FRACTIONS BETWEEN S		POT VOL CMANGE (-)0.055 IN.S		(-,0,75 IN.SIZE SPECIF GRAVITY	0
KEY IDE: 34 I AW SAM LAW	PUCK DU PER PER PER PER PER PER PER PER PER PER	HS	Ł	( d	6	200	2.30

					ers.
			ONOARY 480V	1	
0		POWER SYSTEM	PRIMARY SECONOARY 4160V \$80V		w
	1.	POWE	PRI4		SHOTCRETE
U			d z	i	3
		UTILITY LINES	AIR WATER PUMP 6IN 2IN 6IN		SET.SIZE.SHAPE
		UTILI	AIR SIN	4	SET
8		WATER INFLOW	9		PLATE
П		WATER	6PM 40-120		BOLT. TYPE SIZE ROOF PLATE
	•		Ŧ	SUPPORT SYSTEM	TYPE SIZ
U			PRESS EXHST SIZE X 28IN	SUPPOR	BOL T.1
			EXHST X		
		ILATION	PRESS		SUPPLY RAIL
		VENTIL	CFH 20X		
			GRADE CFM +0.25PCT 20K		PERSONNEL RAIL
					PER
	DATA		SHAPE	HAULALE SYSTEM	
	KEY 34A TUNNEL DATA	TUNNEL	SIZE I3FT 8IN	AULACE	MUCK
	₹ ₹	F	SH	Ĩ	īã

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	THRUST. HAX/OPERATE		KLB · KRB · KLB 614	
, ţ	TORQUE. MAX/OPERATE	10 CENTER	KFTLB KFTLB KFTLB KFTLB	
	RPH TO	HEAD, CENTER HEAD	3	
	965	GAGE TOP	IS IN OISC. II ISIN ROLLER TOB ISIN ROLLER	
	UTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	INTERIOR	ISIN 015C+ II TCB ISIN ROLLER	
	CUTTERS . MAKE . TYP	CENTER	24IN TRICONE	
		F 6	TONS	
XCAVATION		MODEL	HANDHOCK .	
MACHINE EXCAVATION	MACHINE	MAKE	MENTUN	

THRUST/SQ FT	KLE 4.28	
GUIOANCE		
POWER SYSTEM	HYORAULIC 600HP HEAD	ISO CENTER
MUCK SYSTEM	FACE 24IN	PEAR
ANCHOR PRESS	KLB	

BLASTING							
EXPLOSIVES.	POWOER FACTOR	TOTAL LBS	PRIMERS	TRIM	INTERIOR	5	151506
ROUND.	NO. HOLES	DEPTH	DIAM.	CUT.			
MACHINE	JUF80	MACHINES			FEED LENGTH		

CONVENTIONAL EXCAVATION

MUCKING

		* \$'	2					
	PCT (-)	14.3	= SPHERO			IN.	. S. ~	
	NO 100 NO 200	2°0	A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID PI PI PI PI PI PI PA PA A	TOUGHNESS	50.0	SIZE(-)2.0 I ANGLE INTER FRICTION DEGREES AT 8.8 PCT MOIST	88	
4	00 I 00	~	JLAR E	TOUGHN	•	IST		
4	NO 50	<b>.</b>	= IRREG	8		ISITY AT PCT HOIST	ž	
9	2 0	<b>v</b> uř	PA	FLOR	4:1	100 P		
	31N. ZIN. IIN. I/ZIN. NO NOS NOIG NOIG	÷	PA C	× ×		: 5	1	
100	SCREE	5.1	)ED P#P	PLASTICITY INDEX PCT	01	APPARENT COMESION PSF AT PCT M	300	
6	BETWEEN NOS	7.3	R=ROUNG	12E(+)	0.5	IN		
	WE I GHT	17.0 7	NGULAR 1 P	HITSS KAGE		7 ATE	37	
160	INT BY		S=SUBAN	SHRIN LIMIT PCT	13.5	SIZE(~:2.0 ANGLE7 STEEL DEGREE 8.9 PC		
H	PER CE	18.3	NGULAR P1	PLASTIC SHRINKAGE PL PLASTIC SHRINKAGE PL LIMIT LIMIT PCT		IAL IST		
	. 21N.	5.0		PLASTIC LIMIT PCT	20.0	ANGLE/REPOSE ANGLE/REPOSE DE IN UROP DEGREES AT	\$	
	JIN	o• o	N SCREEN SIZES			8		
	ž		N SCR	QUID MITS	N.	SE 1ST		

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SHORE MON SCHMIDT

ROD PCT EST

COMPR STRNTH KPSI

08 ₹ 1 ₹

POCK PROPERTIES
SEDIMENTARY: LIMESIDNE LIGHT
TO MEDIUM GRAY FINE GRAINEO.
SOME CHERT NODULES. TRACES TO
OCCASIONAL CLAY PARTINGS.

KEY IDENTIFICATION
35 LAWRENCE

SAMPLE NO

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR

PCT (+)6 IN-STZE

MOISTURE PCT

MUCK DATA DEY UNIT WT PCF

0.0

1.9

80

20.5

42

2.73

LIGUID LIMITS . PCT

POT VOL CHANGE (-)0.056 IN.SIZE

	STEM	PRIMARY SECONDARY 4160V - 480V		
	POWER SYSTEM	PRIHARY 4160V	4	SHOTCRETE
		1	٠,	
	2	PUMP		IAPE
	UTILITY LINES	WATER		IZE + SH
	UTILI	AIR 6IN		SET.SIZE.SHAPE
	2			
	WATER INFLOW	2		PLATE
	WATER	GPM 46-120		ROOF
		÷	YSTEM	BOLT.TYPE SIZE ROOF PLATE NONE
			SUPPORT SYSTEM	T.TYPE
		ST SI 28	SUP	NON
	z	PRESS EXHST SIZE		<u>ئ</u>
	VENTILATION	PRES		SUPPLY
•	VENT	CFR 21K		•
		68A0E +0.25PCT 2		PERSONNEL RAIL
Į.		SHAPE	YSTEM	
35A TUNNEL DATA	TUNNEL	SIZE 13FT BIN	HAULAGE SYSTEM	HUCK

KEY

	7		CUTTERS.MAKE.TYF	PE.DIAM. CUTTING ED	GES	RPN	TORQUE + MAX/OPERATE	OPERATE	THRUST . MAX/OPERA
HAK	MAKE MODEL	L A	CENTER	CENTER INTERIOR GAG	GAGE	HEAD CENTER HEAD	HEAD	CENTER	
		TONS	24IN TRICONE	15 LANGUE ICB. 3 LANGUEER 15 IN DISC. 11 ISIN MOLLER	ISIN MOLLER	000	KFTLB	KFTLB	KLB.

THRUST/SQ FT	ห <b>ุษ 3.7</b> 6
GUIDANCE	
POWER SYSTEM	HYORAULIC 600HP 150 HEAD
MUCK SYSTEM BUCKETS FROM	FACE, 24 IN CONVEYOR TO REAR
PRESS	
ANCHOR	KL8

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LASTING MUCKING	
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EXPLOSIVES, POWDER FACTOR TOTAL 1.85 PRIMERS,	TRIM INTERIOR CUT
ROUND, NO. HOLES DEPTH DIAM.	
HACHINE HACHINES	FEED LENGIH

GUIDANCE

MACHINE EXCAVATION

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	PCT (~) NO200 7.6	P=SPHEROID			TER AT HOIST	*
: <u>:</u>	NO200	A=ANGULAR S=SUBANGULAR R=KOUNDEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROLD PE PI PI PI PA S S S	TOUGHESS	0.24	SIZE(-)2.0 ANGLF INTER FRICTION OEGREES AT 3.5 PCT HOIS	**
HARONESS	2.0	REGULAR	DI		*• HOIST	
₩ ₩	~	2081C 1=1f	FLOW	2.00	BULK DENSITY PCF AT	* <b>2</b>
PCT SHOD SEST NA		PLATY Cat	NI YTT		APPARENT CAMESION PSF AT 1 PCT HOIST	&
44 44 44 44 44 44 44 44 44 44 44 44 44	BETWEEN SCREENS NOB NOIG 3.2 6.2 4.8	OUNDEO Pa	(-) 0.056 PLASTIC INDEX PCT	1.21	•	20,5
Neva II	WEIGHT BE	4GULAR R=6	1175S12E (AGE		SLIOE SLIOE PLATE S AT	30
	ENT BY IZZIN	AR S#SUBAW	REERS LINSTER	15.46	SIZE(-)2.0 ANGLE/SLIDE STEEL PLATE OEGREES AT 2.5 PCT MO!	
PERTIES ARY: LIMESTONE, GRAY INEO: MURIZONTAL ACING 6 IN. TO I FOOT.	31N. 2	SCREEN SIZES A=ANGUL!	PLASIIC SHRINKAGE PLASIICITY INDEX INDEX PCI	15.69	ANGLE/KEPOSE 10 IN UKOP OEGREES AT 2.5 PCI MOIST	35
ROCK PROPERTIES SEOTMENTARY: LI FINE GRAINEO. H JOINT SPACING 6	PCT(+)6 IN.SIZE 6IN.		LIOUIO LIMITS PCT	16.90	ANGLE/REPOSE I IN OROP PEGFEES AT	36
IDENTIFICATION WILMAUKEE SAMPLE NO MIL-I	K OATA Y UNIT MOISTURE PCF PCT 89 5.5	SHAPE OF FRACTIONS BETKEEN	POT VOL CHANGE (-)0.056 IN.SIZE		(-)0.75 IN.SIZE 4. SPECIF ANG CRAVITY IN	5.89
36 36	M D B D C K K K K K K K K K K K K K K K K K K				Hi)	

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STEM	PRIMARY SECONDARY		
POWER SYSTEM	PRIMARY 4680V	0	SHOTCRETE
UTILITY LINES	AIR WATER PUMP 6IN IIN 6IN		SET+51ZE+SHAPE 4IN H RING SETS IN FAULT ZONES
MATER INFLOW	6рм 5.		ROOF PLATE OCCASIONAL PINNED STEEL . LAGGING
3	SIZE HP GF 191N 25 5.	UPPORT SYSTEM	BOLT.TYPE SIZE RO
/ENTILATION	DESS EXHST	n	SUPPLY B
VEN	GRADE CFM +0.2PCT 4K		PERSONNEL RAIL
TUNNEL	SIZE SHAPE LIFT ROUND	HAULAGE SYSTEM	HUCK RAIL, Z4IN GAGE STON MOTORS

#### MACHINE EXCAVATION

THRUST.MAX/OPERATE KLB 1104 KLB 596	
TORQUE,MARYOPERATE HEAD CENTER KFTLB 170 KFTLB KFTLB	
RPH TORGA HEAD GENTER HEAD 9.3 INTEG KFTLE	
CUTTERS.MAKE.TTPE.UIAM.CUTTING EDGES  ENTER INTERIOR GAGE I REED STEEL 4 REED STEEL CONE, 5 DISC THIPLE OISC TRIPLE DISC	GUIDANCE THKUSI/SQ FT LASER KLB 6.09
CUTTERS, MAKE, TYP CENTER 1 REED STEEL CONE, S DISC	POWER SYSTEM 6-50HP MOTORS FOR HEAD 1-40HP MOTOR HYDMAULIC
400FL #T 11-1100 65	ESS MUCK SYSTEM BUCKET FROM CONVEYOR TO MEAR
HACHINE HAKE JARVA	ANCHON PRESS KLB 1650

### CONVENTIONAL EXCAVATION

MUCKING	
BLAST : NG	
EXPLOSIVES. POWDER FACTOR TOTAL LBS PRIMERS.	TRIM INTERIOR CUT
AOUND. NO. HOLES DEPTH DIAM.	CU1•
MACHINE JUMBU MACHINES	FEED LENGTH

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		PCT (-)	<b>\$</b>	P=SPHEROID		70 · · · · · · · · · · · · · · · · · · ·		IN.	
*10 *10	<b>\$</b>	NO100 NO200	9:	A=ANGULAR S=SUBANGULAR R=ROUNDEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHERGID		TOUGHNESS	95.0	SIZE(+)2.0 I ANGLE INTER FRICTION DEGREES AT S.0 PCT MOIST	* : 20* :
HARDNESS	₹ 2		. 1.	I=IRREGULAR	v	2 9		BULK OENSITY PCF AT	8
SHORE	<b>\$</b>	NO30 NOS0	9 2.1	Y C=CUBIC	v	FLOW	6.10	o ist o	44 \$
R ROD	88	22N. IIN. I/2IN. NO4 NO8 NOIG	8.	4DEO P=PLAT	e S	9 0.65&IN.PLASTICITY INDEX PCT	3.42	APPARENT COMESION PSF AT	* OI
COMPR STRNTH KPSI	<del>ల</del> ో	IGHT BETWEEN	8 11.5	ULAR R=ROUN	I	TS\$12E(~!) GE	ŕ	IN. LIDE LATE AT HOIST	
DAY PCF	19 <b>9</b>	PER CENT HY WEIGHT	24.7 22.8	K S=SUBANG	Id	RBERG LIMI SHRINKA LIMIT PCT	16.37	SIZE(-)2.0 ANGLE/SLIDE SIEL PLATE OEGREES ALT 5.8 PCT MOI:	30
RRIES RY: LIMESTONE, GRAY, VED. HORIZONTAL JOINT IN. TO I FOUT.	ensk 2e	JIN.	3.0 0.0 9.2 2		<b>a</b>	**************************************	16.68	ANGLE/MEDOSE ANGLE/MEDOSE 10 IN UROP DEGREES AT 5.8 PC1 MOIST	. 00
ROCK PROPERI SEDIMENTARY: FINE GRAINEC SPACING 6 IN		PCT(+)6IN.SIZE 6IN.	0.0	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES		Liguio Livits PCT	20.10	ANGLEREPOSE I IN ORDP DEGREES AT	32
IDENTIFICATION MILWAUKEE SAMPLE NO		CATA UNIT MOISTURE PCF PCT	6.1	PL OF FRACTION		POT VOL CHANGE (-)0.056 IN.SIZE		(-)0.7S IN.SIZE 0. SPECIF AN GRAVITY DE	
KEY IDENTI 37 MILWAL SAMPLE MIL-2		MUCK DAT	os er	SHA	b	100	•	SPFC GRAV	2.93

	POWER STATEM	PRIMARY SECONDARY 4680V 440V	3	*
	MO d	A 4		SHOTCZETE
	UTILITY LINES	AIR WATER PUMP 6IN 11N 6IN		SET.SIZE.SHAPE 4IN H RING SETS IN FAULT ZONES
	MATER INFLOW UT	A16		ROOF PLATE SE OCCASIONAL 411 PINNED STECL FAI LAGGING
	40	P 01	EX	ZE ROOF OCCAS PINNE LAGGI
		ZE #5	SUPPORT SYSTEM	SDLT.TYPE S1ZE
		PRESS EXHST SIZE X 181N	Sup	T)
	VENT1LAT1DN	PRESS		SUPPLY
	VE	GRADE CFM +0.25PCT 4K		PERSONNEL Rail
DATA		SHAPE	AULAGE SYSTEM	4UCK RAIL, 24IN GAGE STDN MDTORS
37A TUNNEL	TUNNEL	S12E 11FT 21N	HAULAGE	HUCK RAIL.

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KEY

THRUST • MAX/OPERATE KEB 1104 KEB 596	
TDRDUE, HAX/DPERATE HEAD CENTER KFTLB 175 KFTLB KFTLB	
RPM TORDU-HEAD.CENTER HEAD 9.3 INTEG KFTLB	
G EDGES GAGE GAGE TRIPLE DISC	GUIDANCE THRUST/SQ FT LASER KLB 6.09
E.DIAM.CUTTING INTERIOR 22 REED STEEL TRIPLE DISC	
CUTTERS, MAKE, TYPE, DIAM, CUTTING EDGËS CENTER 1 REED STEEL 22 REED STEEL 4 F CONE, 5 DISC THIPLE DISC TR	POWER SYSTEM 6-50HP MOTOMS FOR MEAD. 1-40HP MOTOR HYDRAULICS
N 200 HT 2005	MUCK SYSTEM BUCKET FRCM FACE, 18TK CONVEYOR TO REAK
MACHINE EXCAVATION MACHINE MAKE MODEL JARVA 11-1100	ANCHOR PRESS MU BU KLG 1650 FA CC

HUCKING BLASTING EXPLOSIVES.
POWDER FACTO
TOTAL LBS
PRIMERS.
PRIME
INTERIOR
CUT RDUND. NO. HDLES DEPTH Ulam. Cut. FEED LENGTH MACHINE JUMBD MACHINES

CONVENTIONAL EXCAVATION

GUIDANCE

	PCT (-)	15.8 8	=SPHEROID		Š.		. IN.	
CHWIOT	NOSO NO100 NO200	<b>ه</b> .	A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC 1=1RREGULAR E=ELONGATED SP=SPHEROID		TOUGHNESS	0.22	SIZE(-)2.0 IN ANGLE INTER FRICTION OEGREES AT 17 2.3 PCT MOIST	20 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
SHORE MON SCHMIOT	N 030 N030	1.2	CUBIC 1=1RREGUL	v	FLÖB INDEX	3.50	BULK OENSITY PCF AT IST 0.0 PCT MOIST	8
ROD HI PCT		3.1 2.0	JUNDED PEPLATY C	ν <b>4</b>	(+) 0.056IN PLASTICITY INDEX PCT	0.80	APPARENT COMESION PSF AT 2.3 PCT MOIST	• • • • • • • • • • • • • • • • • • •
DRY COMPE	NT BY WEIGHT BET! I/2IN. NO4	7 17.4 4.3	S=SUBANGULAR R=R	Id	PLASTIC SHRINKAGE PLASTICITY SHAIT LIMIT SOUNCE PLASTICITY LIMIT LIMIT PCT PCT	12.95	SIZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE OEGREES AT 2.5 PCT HOIST	8
S INESTONE GREY		0 25.4 32.7	S371S	Id 3d	PLASTIC LIMIT PCT	14.40	ANGLE/REPOSE TO IN UROP OGGREES AT A.S. PCT MOIST	2
ROCK PROPERTIES SEOIMENTARY: LIMESTONE FINF GRAINEO. GREY	PCT(+)6	0	ONS RETWEEN SCREEN		ZE LIGUIO LIMITS PCT	15.20	ANGLE/REPOSE I IN DROP CEGREES AT 2.5 PCT MUIST	36
FY IDENTIFICATION 38 MILMAUKEF SAMPLE NO MIL-3	MUCK DATA DHT UNIT MOISTURE WT PCF PCT	I*S 64	SHAPE OF FRACTIONS HETWEEN		POT VOL CHANGE (-10.055 IN.SIZE		(-10.75 IN.SIZE SPECIF GRAVITY	2.79

CURRENT: 1 SEPT. 1972

Ç.		STEM	SECON 440		,
		POWER SYSTEM	PRIMARY SECON	•	SHOTCRETE
]			<b>₽</b>		
]		UTILITY LINES	AIR WATER PUMP 6IN IIN 6I N		SET.SIZE.SHAPE
]		UTILI	AIR 6IN I	į	SET.
]		WATER INFLOW	~		PLATE
]		WATE	GPH	<b>3</b>	E ROOF
			SIZE HP BIN 25	SUPPORT SYSTEM	BOLT.TYPE SIZE ROOF PLATE NONE
]			EXHST S	ኧ	
]		VENTILATION	CFM PRESS EXHST SIZE HE		SUPPLY
V.		VEN	GHADE CFM +0.2PCT 4		INE
					PERSONNEL RAIL
	KEY 384 TUNNEL DATA	ر ا	SHAPE	HASLAGE SYSTEM	HUCK RAIL 24 IN GAGE 51 HOTOR
	384 TUNN	TUNNEL	SIZE 11FT 2 IN	HALL	PAUCH PAUCH STAIN

	Alg.
THRUST . MAX/OPERATE	KLB KLB 639
ORQUE, MAX/OPERATE	CENTER KFTL8 KFTL8
TORQUE, MAX	HEAC KFTLB KFTLB119
₹ dq	HEAO.CENTER HEAD 9.3 KFTLB KFTLB
G EUGES	GAGE 4 REED QK-5
KE.TYPE.UIAM.CUTTING EDGES	INTERIOR 22 REED 2K3
CUTTERSOMAKE	CENTER 1 REED 0x-1
	₹ 59 65
CAVATION	**************************************
PACHTHE FREAVATI	ANT ANT ANT ANT ANT ANT ANT ANT ANT ANT

HRUST/SQ FT
GUIOANCE THR LASER KLA
POWER SYSTEN 6-50HP MOTORS ORIVE MEAO
HUCK SYSTEM BUCKETS TO BELT
ANCHOR FRESS

	EXPLOSIVES. POWOER FACTOR TOTAL LBS	TRIM INTERIOR CUT
VATION	ROUNG. NO. HOLES OFPTH	CUT.
CONVENTIONAL EXCAVATION	MACHINE JUMBO MACHINES	FEEO LENGTH

SCHMIDT	
SHORE MDH SCHMIDT	
800 PCT	100
COMPR STRNTH KPSI	92
PCF	168
ROCK PROPERTIES SEDIMENTARY: LIMESTONE FINE GRAINED. LIGHT GREY	
SO MT GREEN	

		PCT (-)	8.7
		6.N. 31M. ZIN. IIN. I/ZIN. NO4 NO16 NO16 NO30 ND50 NO100 ND200 ND200	
		N NC	5.4
		ION	
	·	NDSO	0
		N030	٠ ر
	100	SCREENS.	, 11
KPSI	92	ETWEEN S	П
		EIGHT B	0 3.2 26.6 22.1 21.5 4.3 3.7 3.3 2.0 2.2
40	168	ENT BY V	15
		PER C	6.6 22
		21N.	3.2
		IN. 31X	
GREY			
. 3		E PCT(+)6 IN.SIZE	0
9		MDISTURE PCT	3.8
SAMPLE ND	E V 6-1	K DATA Y UNIT	96
J. ,		MUCK DRY WT	

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID

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TOUGHNESS	0.47	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 3.0 PCT HDIST	* * * * * * * * * * * * * * * * * * *
		1TY NT OCT H01ST	104
FLOW	3.0	BULK DENSI PCF	,
(-) 0.056INPLASTICITY INDEX PCT	1.41	APPARENT BULK CDHESION DENSITY PSF AT PCF AT 3.0 PCT MDIST 0.0 PCT MOIST	70
PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT INDEX PCT PCT	11,57	SIZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE . DEGREES AT . DE GREES AT . D. D. D. D. D. D. D. D. D. D. D. D. D.	31
PLASTIC LIMIT PCT	13.69	ANGLE/MEPDSE ANGLE/SL 10.10 JNOP STEEL PL DEGREES AT DEGREES 3.1 PCT HDIST 2.1 PCT	16
LIMITS	15.10	E/REPOSE DROP EES AT PCT MDIST	100
POT VDL CHANGE (-)0.055 IN.SIZE		(-)0.75 IN.SIZE ************************************	37
1 VDL C		0.75 IN FCIF AVITY	2.81
8.	0	.) gg	2

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	SCOOLAT		THRUST, MACOPETANE KLB . KLB 230		
w)	PHINAIP SCO	SHOTCRETE	K/OPERATE CENTER KFTLB KFTLB	V.	MUCKING
	UTILITY LINES AIR WATER PUMP 3 IN	SET.SIZE.SHAPE	RPH TORQUE, MAK/OPERATE HEAD.CENTER HEAD CEN É KFTLB KFTLB KFTLB		BL AST 1NG
	WATER INFLOW GPH 400	IZE MOOF PLATE	G EDGES GAGE 6 ROBBINS 12 IN DIA DISC	THRUSE/SO FT	EXPLOSIVES. POWDER FACTOR TOTAL LBS PRINERS. INTERIOR CUT
	S12E HP 301N 90	SUPPORT SYSTEM BOLT.TYPE SIZE NONE	AKE.TYPE.LAM.CUTTING EDGES INTERIOR GA Z ROBINS 6 12 IN DIA 12 015C DI	GUIOANCE	EXPLOSIVE POWDER F. 107AL LB PRIMERS- TRIME INTERIOR CUT
	VENTILATION CFM PRESS EXHST 18	SUPPLY	CUTTERS.MAKE.TYPE CENTER 3 ROBBINS 11 IN DIA OISC	POWER SYSTEM 4-100 MP MOTORS ORIVE HEAD	RGUNO. NO. MOLES DEPTH DIAM. CUT.
	GRADE •0.2PCT	PERSONNEL RAIL	1 3 7 8 8 0 1 8 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	HUCK SYSTEM HUCKET TO BELT XCAVATION	2 2 3 5 ·
OATA	SHAPE	4 IN HAULAGE SYSTEM HUCK PAIL 4CY CARS ST WOTO? 24IN GAGE 54 LB RAIL	MACHINE EXCAVALION MACHINE MAKE MODEL ROBBINS 105-144	ANCHOR PRESS MUCK SYSI HUCKET TO BELT CONVENTIONAL EXCAVATION	ES ENGTH
KEY 39A TUNNEL DATA	TUNNEL SIZE IOFT	HUCK PAIL CT CARS ST WOTOR S4 LB RAIL	MACHINE MACHINE MOBBINS	ANCHOR KLB CONVENT	MACHINE JUMBO MACMINES MACMINES

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	PCT (~) NO200
SCHIOT	IN. 31N. 21N. IIN. I/2IN. NO4 NO8 HOI6 NO30 NO50 NOI00 NO200
SHORE MON SCHILLOT	NO30 NO50
900	N SCREENS
COMPR STRVÍM KPSI NA	16HT BETWEEI NO4 NO8
A PCF	PER CENT BY WE IIN. 1/21N.
ROCK PROPERTIES SEDIMENTARY: LIMESTONE FINE CRAINEO. LIGHT GREY	61N. 31N. 21N.
ROCK SEDING FINE GENET	PCT (+)6 IN-SIZE
KEY IOENTIFICATION 40 HT GREEN SAMPLE NO EVG-2	MOISTURE PCT(+)6 PCT IN.SIZE
IOENTIFICAT HI GREEN SAMPLE NO EVG-2	MUCK DATA DRY UNIT
¥ 4 •	žo*

SHAPE OF FPACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNOEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID

5.9

4.6

2.3

3.0

3.0

17.8 4.8

24.2 26.7

2.2

2.5

	ER I
OUGHNESS	SIZE(=) ANGLE INTER FRICTION DEGREES AT PCT MOIST
	SITY AT PCT HOIST
FLOW	200
	70151
PLASTICITY INDEX PCT	INAPPARENT TE COMESION T PSF AT OIST PCT KOIST
S12E (-	N. TS
ERBERG LIMITS SHPINKAGE LIMIT PCI	SLI PLA TS A
LIMITS LIMIT LIMITS.SIZE(-) LIMITS LIMIT LIMIT PCT PCT PCT LIMIT PCT PCT LIMITS LIMIT PCT PCT LIMITS LIMIT LIMIT PCT PCT LIMITS	ANGLE/REPOSE ANGLE/ TO IN UNDO STEEL DG MES AT OLGREE PCI MOIST PE
LIOUIO LIMITS PCT	IN.SIZE ************************************
POT VOL CHANGE (-) IN.SIZE	N.SIZE ANG
8	-) SPECIF SPAVITY
<u>.</u>	338

		ě	SECONDARY SECONDARY	18.54			THRUST . MAX/GOES	55			
		MILE COMME	7400 7400		## TOPO TOPO TOPO TOPO TOPO TOPO TOPO TO	0.0	CONTRACT	25 and			
		m	1		ğ		TORGUE, MALADATRATE				•
		UTILITY : INES	AL MARKET		SCT-STATES UNC			NEAD, CEATER			
		MATER INFLOW	6PM 600		ROOF PLATE	p.	oees	GAGE 2 ROBBINS 12 IN DIA 01SC	THRUST/SQ FT		C108
		•	30 IN 90	SUPPORT SYSTEM	MONE SIZE		.UIAM.CUTTING ED	INTERIOR 21 ROBBINS 12 IN DIA DISC	GUIDANCE THRI		EXPLOSIVES. POWOER FACTOR TOTAL LBS PRIMERS. TRIM INTERIOR CUT
		VENTILATION	CFN PRESS EXHST		SUPPLY		CUITERS, MAKE, TYPE, DIAM, CUTTING EDGES	CENTER 3 ROBBINS 11 IN OIA DISC	POWER SYSTEM 4-100 HP MUTORS URIVE MEAD	?	ROUND. NO. HOLES DEPTH OIAH. CUT:
			GRADE +0.2PCT		PERSONNEL	104		18 75 75 10NS	MUCK SYSTEM BUCKET TO BELT	CAVATION	ROUND NO. H DEPTH OIAN. CUT.
	40A TUNNEL DATA	ر	SHAPE	HAULAGE SYSTEM	MUCK FAIL 5T MOTOF 54 IN GAGE 54 LB RAIL	MACHINE EXCAVATION	13E	(E MODEL INS 105-144	ANCHOR PRESS	CONVENTIONAL EXCAVATION	MACHINE JUHAO HACHINES FEED LENGTH
KEY	40A TUNNEL	TUNNEL	S12E 10 FT 4 IN	HAULA	MUCK FAIL 4CY CARS 5T MOTOP 24 IN GAG 54 LB RAI	MACHI	MACHINE	MAKE ROBBINS	ANCH KLB	CONVE	MACHINE JUHAO HACHINES

SHORE MOH SCHHIDT	ž	
HARDN MDH	4 N	
SHORE	4	
PCT FST	. 40	
COMPR STRNTH KPSI	10	
PET P	159	
ROCK PROPERTIES SEDIMENTARY: SANDSTONE MEDIUM GRAINED, LIGHT BROWN TO RED. MASSIVE, PORDUS, POORLY	CERENTED	
IDENTIFICATION LAYOUT SAMPLE ND	LAY-1	
# <del>4</del>		

PCT (-) N0200	7.52
SIN. 21N. 11N. 1/21N. NO4 NOB ND16 ND30 ND50 NO100 NO200	
0100	. 4
920	15.4
Q Q	1.6
F ND	2.7
N SCREEN	3.4
BETYEE	9
VEIGHT	12.6
CENT BY	7.6 7.5 5.7 12.0 12.6 4.6 3.4 2.7 1.8 15.4 1.0
PER 11N.	5.7
IN . 210	7.5
	7.6
PCT(+)6 IN-SIZE	
	0.0
MOISTURE PCT	;
DCK DATA 30°Y UNIT WT PCF	105
J. S. P.	

A=ANGULAR S=SUBANGULAR R=RDUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROTO SHAPE OF FRACTIONS BETWEEN SCREEN SIZES

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		ER IN.	
TOUGHNESS	0.52	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 3.6 PCT MOIST	8
	00.9	APPARENT BULK COMESION DENSITY PSF AT PCF AT 3.6 PCT MDIST 0.0 PCT MDIST	4.76
-) 0.056ININDEX	3.14	APPARENT COHESION F PSF AT 3.6 PCT MDIST	210
PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT NDEX PCT	15.17	MAGLESTIDE ANGLESTIDE STEEL PLATE DEGREES AT 3.6 PCT MDIST	12
PLASTIC LIMIT PCT	17.06	ANGERIAL SIZE(-)2.0 ANGLE/KEPOSE ANGLE/SL IO IN URDP STEEL PL DEGREES AT DEGREES 3.6 PCI NOIST 3.6 PCT	35
LIOUD	21.20	GCE/REPDSE IN DROP GREES AT PCT MOIST	37
POT VOL CHANGE (-)0.656 IN.SIZE	0	(a)0.75 IN.SIZE ************************************	99.2

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	No.	STEM	SECONOARY 480V				THRUST. HAX/OPERATE	KLB 900 KLB 357AV			GUIDANCE
		POWER SYSTEM	PRIMARY 7300V		SMOTCRETE	h	OPERATE	CENTER KFTL8 KFTL8		\$E	MUCKING
	÷	UTILITY LINES	AIR MATER PUNP 61N 3.51N 81N		SET.SIZE.SHAPE 4IN M RINGS AT 4FT		RPM TORQUE+MAX/OPERATE	HEAD CENTER HEAD 5.2 INTEG KFTLB NA OR 2.6 KFTLB 498AV			BLASTING
		WATER INFLOW	E HP GPH 103 .20-100	DRT SYSTEM	BOLT.TYPE SIZE MOSF PLATE 3/41N X 7FT. 131N X 9FT 10PCT	,	CUTTING EDGES	INTERIOR GAGE 23 ROBBINS 111N 6 ROBBINS 121N 51EEL 01SC STEEL DISC	GUIOANCE THRUST/30 FT LASER RLB 2.73		EXPLUSIVES. POWDER FACTOR TOTAL LBS PRIMERS. PRIMERS. INTERIOR CUT
		VENTILATION	CFM PRESS EXHST SIZE TIS-17K X 361N	SUPPORT	SUPPLY BOLT- RAIL 3/41N		CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	CENTER INTER 1 ROBBINS 111N 23 RO STEEL THIPLE SIEEL DISC	POWER SYSTEM 6-100MP MOTORS FOR MEAD		ROUND. NO. HOLES DEPTH OIAM. CUT.
KEY	14 TUNNEL DATA	TUNNEL	SIZE SHAPE GRADE CFM IZFT ROUND +0.125PCTIS-17K	HAULAGE SYSTEM	MUCK RAIL. 24IN GAGE RAIL 65LB RAIL. 10TON MOTORS	MACHINE EXCAVATION	MACHINE	MAKE MODEL WI ROBBINS 14127 125 TUNS	ANCHOR PRESS MUCK SYSTEM BUCKETS FROM KLB 1000 FACE, 301N CONVEYOR TO REAR	CONVENTIONAL EXCAVATION	MACHINE RO JUMBO MACHINES DE PEEO LENGTH

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	PCT (-)	₹ , 	P-SPHEROID		e de seri	
••••••••••••••••••••••••••••••••••••••	NO106 NO200	3	K E=ELONGATED S	TOUGHNESS	(+) 2. 3/E 11. 3/E 13.	3.0 PCT 180
SHORE NON SCHAIDT	NO50	5.0 4.0	JBIC I=IRREGULAE	FLOW	O XXX	0.0 PCT MOIST
Red PCT		0.4	DED P=PLATY C=CI	PLASTICITY INDEX PCT	ARENT FESTON	3.0 PCT H01ST
DRY COMPR WT STRNTH PCF KPSI NA NA	PER CENT BY WEIGHT BETWEEN SCREENS. Zin. IIN. 1/Zin., ND4 NO8 NO16	23.0 8.0	A=ANGULAK S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAK E=ELONGATED SP=SPHEROID  P P-A A A A A A A A A A A A A A A A A A	**************************************	SLIDE PLATE 5 AT	b PCT 401ST
IGLOMERATE LLES TO ZITE AITH NUSTONE	3IN. ZIN. IIN. 1/2	30.0		PLASTIC SY LIMIT LY	I4.18MATERIAL SIZE SLE/KEPOSE IN UROP GRES AT	151
ROCK PRUPERTIES SEDIMENTARY: CONGLOHERATE WELL GRADEO COHBLES TO WEBLES OF OUMSTITE PODDRY CEMENTED ATTH REDDISH BROWN SANDSTONE	PCT (+)6 ************************************	•	IS RETVEEN SCREEN SIZES	LIOUID LIMITS PCT	IS.00 GLE/REPDSE IN DROP GREES AT	PCT MOIST 3
42 LAY SAMPLE ND LAY-2	MUCK DATA DAY UNIT MOISTURE WI PCF PCT	104 3,3	SHAPE OF FRACTIONS RETWEEN	POT VDL CHANGE (-)0.056 IN.SIZE	0 (-)0.75 IN.SIZE *. SPECIF ANGRAVITY DE	3.65

FEED LENGTY

							ATE				b l
6		<b>.</b>	SECDNDARY 460				THRUST, HAX/OPERATE	KLB S95			GUIDANCE
		POWER SYSTEM	PRIMARY SI 7300		ETE	4	a	CENTER LB LB		,	9
	f .	8	ď.		SMOTCRETE	3	TORQUE . MAX/OPERATE	KFT KFT			MUCKING
			PUMP		w		TORQUE . M.	HEAD KFTLB KFTLB491		y	BLASTING
		UTILITY LINES	WATER P		SET.SIZE.SHAPE 4 IN F FULL RINGS IN BAD GROUND			ENTER JR			3
	1.0	UTILI	AIR 61N		SET.SIZ		A G				
		WATER INFLOW	8		RODF PLATE			GAGE 6 RDBBINSIZIN DIA DISC	t		
		WATE	GPH 20-100	Z W			EOGE'S	6AGE DIA	THKUST/SQ FT		FACTOR BS
			SIZE HP 36IN 100	SUPPORT SYSTEM	BOLT. TYPE SIZE		CUTTERS.MAKE.TYPE.UIAM.CUTTING EDGES	INTERIOR 23 ROBBINS II IN DIA DISC	SYSTEN GUIDANCE 1 HP MOTORS LASER HEAD		EXPLUSIVES, POWOER FACTON TOTAL LBS PHIMEPS,
		7	EXHST				KE.TYPE.		YSTEN P MOTORS EAD		
		VENTILATION	CFM PRESS TIS-7K		SUPPLY RAIL		CUTTERS.MA	CENTER I ROBBINS IIIN TRIPLE OISC	POWER 6-160 ORIVE		ROUND. NO. HOLES DEPTH OIAM.
			GRADE CFM •0.125PCTI5-7K		PERSONNEL RA IL			125 10N	MUCK SYSTEM BUCKETS TO BELT	ATION	2200
			SHAPE	SYSTEM		CAVATION		MODEL 141-127		AL EXCAV	
	KEY 42A TUNNEL DATA	TUNNEL	SIZE SH IZ FT PC II: IN	HAULAGE SYS	MUCK RAIL IO CY CAPS IO' MOTOR 24 IN GAGE 65 LB RAIL	MACHINE EYCAVATION	MACHINE	MAKE ROBBINS	ANCHOR PRESS	CONVENTIONAL EXCAVATION	HACHINE JUNBD HACHINES
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8E5E : : : : : : : : : : : : : : : : : :
ROCK PROPERTIES SEOINTNIARY: SILVE SEOINTNIARY: SILVE PCT FELOSPAR, IS PCT CHLOPITE AND GYPSUM, IN.SIZE 6IM, 3IM, 0.0 12.1 7.6 0.0 19.1 0.1 UPPER LINE, DRY SCREEI NS RETWEEN SCREEN SIZE RS RETWEEN SCREEN SIZE NS RETWEEN SCREEN SIZE NS RETWEEN SCREEN SIZE NS RETWEEN SCREEN SIZE NS RETWEEN SCREEN SIZE NS RETWEEN SCREEN SIZE NS RETWEEN SCREEN SIZE NS RETWEEN SCREEN SIZE NS RETWEEN SCREEN SIZE NS RETWEEN SCREEN SIZE NS RETWEEN SCREEN SIZE NS RETWEEN  ROCK PROPERTIES SEOINTNARY: ST GRAINED GRAY. PCT FELDSPAR, II CHLORITE AND GRI CHLORITE AND GRI O.0 12.1 UPPER LINE, DRY S NS RETWEEN SCREEN SECTE 30.60 30.60 30.60 30.60 IN SPOP EGREES AT T PCT HOIST
ROCK PROPER SEGIMENTARY GRANTZARY GRANTZARY GRANTZARY CHLORITE AN IN-SIZE GIN O.0 UPPER LINE, D UPPER LINE, D LIMITS PCT SPCT SPCT SPCT 30.8C IN DROP EGREES AT T PCT HOIST
PCT TELLOHING UPPER LIN SRETWEEN NS RETWEEN NGLE/REPORT IN SROPE L
NS AS TO SEE STATE OF SEE STATE
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S: S: Z: Z: Z: Z: Z: Z: Z: Z: Z: Z: Z: Z: Z:
DATA  DATA  UNIT POLT  UNIT POLT  CREEN ANALYSIS:  CANALYSIS:
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SAMPLE NO NAV-1  SAMPLE NO NAV-1  SAMPLE NO NAV-1  SCREN ANALYSIS: SCREN ANALYSIS: SHAPE OF FRACTI  SCREN ANALYSIS: SHAPE OF FRACTI  1.3  1.3  1.3  1.3
POT (-)6 SPEC GRAPE SCRE

NAV-1

TUNNEL DATA	ATA									
TUNNEL			VENT	ENT ILATION				WATER INFLOW	UTILITY LINES	POWER SYSTEM
S12E 20FT 61N	SHAPE	GHAGE CFM PRESS EXHST SIZE *0.05PCT 18K X 301N	CFH 18K	PRESS	EXHST	S12E 301h	48	и е В	AIR WÂTER PUMP 6IN 4IN	PRIMARY SECONOARY
HAULAGE SYSTEM	SYSTEM					SUPPORT	SUPPORT SYSTEM			
MUCK RE:L. 24 76LB. 16	24IN GAGE 16CY CARS HOTOR	PERSONNEL Rail		SUPPLY	II <b>→</b>	3/41N 3 10FT SE LPOXY	PE SIZE LAFT OR I IN	GOLT.TYPE SIZE ROOF PLATE 3/4IN & BFT OR SFT ON 13FT 10FT SET IN 16 GAGE LPOXY	SET+S1ZE+SHAPE	SHOTCRETE TO PREVENT AIR SLACKING

ATE			
THRUST, MAX/OPERAT		KLB 1583	
OPERATE	CENTER	KFTLB KFTLB	
TORQUE . MAX/OPERATI	HEAD	KFTLB 879 KFTLB 586	
ВРМ	HEAO, CENTER HEAO		
GES	GAGE	IC DISCS	
UTTERS.MAKE.TYPE, UJAM, CUTTING EDGES	INTERIOR	SIEEL DISC+ 26 TC DISCS KENNAMETAL TCB	PICK BITS
CUTTERS.MAKE.TYPE	CENTER AIN CHISEL	6 KENNAMETAL TC PICK BITS	
	130		
	MODEL		
MACHINE	MAKE	275	

THKUST/SO FT	KL6 1.31
GUIDANCE	
POWER SYSTEM	MOTORS FUR HEAD 1-75HP MOTOR. HYORAULICS
WICK SYSTEM	FACE, 36IN CUNVEYOR TO REAR
ANCHOR PRESS	KLB 6616

CONVENTIONAL EACAVATION	VATION	
MACHINE	ROUNO.	EXPLO
JUMBO	NO. HOLES	POWOE
MACHINES	0EPT¥	TOTAL
	DIAM.	PRIME
	cut.	TRIM
FEED LENGTH		TALER
		1

MUCKING

BLASTING

MACHINE EXCAVATION

PCT (-) ND200 NG P=SPHERDIE	
THE STATE OF THE STATE OF THE SCHILL	TOUGHNESS
SHORE MOH SCHHIDT NA NA NA 12.7 10.0 7. LDWER LINE, SCREENED B	
SHORE  NA  NO30 R  LOVER LI  TY C=CUBIC I	FLOW
ERTIES RY: SANDSIONE GRAY BRIEGO, MASSIVE. NO POROUS. GRAINS O SUBHOUNDED, OUARTZ. POOMLY II7 1.ESS THAN I.  O.0 0.0 0.0 1.3 2.5 2.3 II.8 23.2 O.0 0.4 IZ.6 I9.6 ONY SCREENEU (ASTM CI36). AFTER WASHING (ASTM CI17).  AI AI AI A AI AI AI AI AI AI AI AI RE AI	PLASTICITY INDEX PCT
COMPR SIFATH RESS THAN I. 1647 BETWEEN SC NO4 NO8 2.3 II. R WASHING (ASTH	15SIZE(=)
DRY WI I I I I I I I I I I I I I I I I I I	RBERG LIMITS SHRINKAGE LIMIT PCT
NE GRAY SIVE. GRAINS GRAINS ED. DOLLY  ZIN. IN. I/ZIN. NO. ZIN. II.2 2.5 TIZ.6 I9.6 VEU (ASTH CI36). AFTER W S A=ANGULAR S.SUBANGULA AI A AI	PLASTIC SHAINKAGE LIMITS.SIZE(-) 0.056IN. PLASTIC SHAINKAGE PLASTICITY LIMIT LIMIT PCT PCT
RDCK PROPERTIES SEDIMENTARY: SANDSTONE GRAY WEGIUM GRAINEO. WASSIVE. FRIABLE AND POROUS. GRAINS ANGULAR TO SUBROUNDED. FRIENTEO.  SIZE GIN. 3IN. ZIN. I  O 0.0 0.0 0.0  PER LINE. OHY SCREENEU (AST BETWEEN SCREEN SIZES A=ANG	
MR 4 X D	LIOUIO LIMITS PCT
TION TETURE TETE	(-) 0.056 IN.SIZE
EY IDENTIFICATION  SAMPLE ND  NAV-2  NAV-2  NAV-2  NAV-2  SAMPLE ND  SAMPLE N	POT VOL

60	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 8.1 PCT MDIST	<b>82</b>
0.28	100	
05.4	BULK DENSITY PCF AT	8
•	APPARENT BULK COMESION DENSITY PSF AT B.I PCT MOIST 0.0 PCT MOIST	\$\$
1.29		
16.60	SIZE(-)2.0 ANGLE/SLI STEEL PLA OEGREES A E.G. PCT H	35
16.91	ANGLE/REPOSE ANGLE/SLIDE ANGLE/REPOSE STEE PLATE OF OFFICE AT OFFICES AT OFFICE AT OFF	58
18.20	SPECIF ANGLE/REPOSE GRAVITY IN OBSPECT OF SPECIF OF SPECIF OF SPECIF OF SPECIFICATION OF SP	31
6	(-) 0.75 IN.SI; SPECIF GRAVITY	2.72

CURRENT: 1 SEPT. 1972

NAV-2

	POWER SYSTEM	PRIMARY SECONDARY 4160V 440V	William Printers	SHOTCRETE TO PREVENT AIR SLACKING
Tel.	UTILITY LINES	AIR MATER PUMP 6IN 4IN		SET.SIZE.SHAPE
	WATER INFLOW	1 CP H		ROOF PLATE SFT OR 13FT 16 GAGE
		30IN 60	SUPPORT SYSTEM	BOLTATYPE SIZE ROOF PLATE 3/4IN X 8FT OR SFT OR 13FT 10FT SET IN 16 GAGE EPOXY
	VENTILATION	PRESS EXHST SIZE	7	SUPPLY BY
	VENT	GRADE CFM +0.0SPCT 18K		PERSONNEL RAIL
KEY 44A TUNMEL OATA	TUNNEL	SIZE SHAPE 20FT ROUND 6IN	HAULAGE SYSTEM	MUCK RAIL. 24IN 34GE 79LB RAIL. 16 CY CARS 15TON MOTOR

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THRUST . HAX/OPERATE	KLB 1583	
TORQUE.MAX/OPERATE	KFILB 586 KFILB	
RPN	HEAD.CENTER 5 INTEG	
CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	CENTER INTERIOR GAGE 4IN CHISEL 30 ORESSER 6 ORESSER 6 KENNAMETAL SIEEL DISC. TC DISC TC PICK HITS ZO KENNAMETAL TC PICK BITS	POWER SYSTEM GUIOANCE THRUST/SO FT -180HP DC L ASEM KLW 0.37 NOTOK HEAD 1-75HF HOTOK.
MACHINE	MAKE MODEL WT CI ORESSER TH-205 200 4 TONS 6	ANCHOR FRESS MULS SYSTEM UCKESS FROM CALL 616 B FACE, 361N SONVEYOR TO REAR

## CONVENTIONAL EXCAVATION

EAPLUSIVES.	POWDER FACTOR	TOTAL 185	PRIMERS.	TRIM	INTERIOR	501	1 TETERS
ROUND.	NO. HOLES	0EPTH	DIAM.	Cu1.			
MACHINE	OP#00	MACHINES			FEED LENGTH		

GUIDANCE

MUCK ING

BLASTING

CHOSE WALL COLUMN		
HARDN		
100A		
000	9	
COMPR	KPSI NA	
DRY	A PC	
	,	
ROCK PROPERTIES SEDIMENTARY: SANDSIONE FINE GRANNED, ROCHN	TO DARK RED. MASSIVE	
KEY IDENTIFICATION 45 ROCHESTER	SAMPLE NO RO-1	
KEY 45		

PCT (-)	11.0
•	
020	
0010	.,
6IN. 3IN. ZIN. 11N. 1/2IN. NO4 NO8 NOI6 NO30 NO50 NOI00 NO200	0 2.0 9.0 12.0 13.0 15.0 7.0 4.0 2.0 2.0 3.0
020	N
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• 61N	
36 2E	
PCT (+)6 IN-SIZE	
	-
MOISTURE PCT	
	4
DATA	
MUCK DATA DRY UNIT	89
Z.	

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID

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F.

역 196* 5	ITER ITER AT HOIST
TOUGHNESS	SIZE(+) ANGLE INTER FRICTION OEGREES AT PCT HOIST
	SITY AT PCT HOIST
FLOW	D S S
	F01ST
ICITY	PARENT FESTON PCT
PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT	APPARENT COMESION PSF AT PCT MOIST
.S12E(	
HITS.	FLATI PLATI
SHRIP SHRIP PCT	E ANGLE/MEPOSE ANGLE/SLIDE ANGLE/MEPOSE STEEL PLATE DEGMEES AT PCT MOIST PCT MOIST
ATTERE	AL SIZ E ST
ASTIC T	MATERI VREPOS UROP CT NOI
712	ANGLE 10 IN DEGRE
1 2g	
LIMITS PCT	EPOSE 20P AT HOIS
w.	NG-E/P
(-) IN.SIZE	IN-SIZE ************************************
رور د	IF IN
100	(-) SPECIF GRAVITY

R0-1

	STEM	PRIMARY SECONDARY 13200 440	No. 49 All.		
	POWER SYSTEM	PRIMARY 13200		SHOTCRETE	
	v	PUSE		P.	
	UTILITY LINES	AIR WATER PUND BIN 41N BIN		SET.SIZE.SHAPE	
	WATER INFLOW U				8 IN. 14 GAGUE
	WATER	40 PM		HOOF PLATE 12FT 6IN OK 8FT & IN X	8 IN
		SIZE HP 48 IN 300	SUPPORT SYSTEM	SFT. 6FT. BFTX S/8 IN 24 IN	CENTER
	LATION	PRESS EXHST SIZE HP X 48 IN 300		SUPPLY	
	VENTI	GRADE CFM +0.045PCT22K		E	
		68 ADE +0.04		PE ISONNEL RA. L	
SATA		SHAPE	SYSTÉM	S. S.	A C E
KEY 45A TUNNEL DATA	TURNEL	S17E 18 FT 4 IN	HAULAGE SYSTEM	MUCK RAIL 10CY CAPS	36 [% G. 15T MOT: 50 LB 82

	THRUST . HAX/OPERATE	265 KLB 492
	TORQUE, MAX/OPERATE	CENTER KFTL8 364 KFTL8
	TORQUE	R HEAD KFTLB364
	RPR	HEAD.CENTER HEAD 11 30 KFTLB KFTLB3
	EDGES	GAGE 5 THC ROLLER
	E.UIAM.CUTTING	INTERIOR 2+ DISC AND 2 TCB ROLLER
	CUTTERS, MAKE, TYPE, JAM, CUTTING EDGES	CENTER 1-24IN TCB TRI CONE
		7.4
MACHINE FACAVATION		MODEL HRT
MACHINE F.	MACHINE	LANDENC

THRUST/SQ FT		KLø	•
GUIDANCE	LASER		
POWER SYSTEM	ELECTRO-	HYDRAUL IC	960 HP
MICK SYSTEM	BUCKET	TO SELT	
ANCHOD DOFCE		K.B	

	Z	
-	AVAT	•
	AL FXC	
	2012	
	22.00	

BLAST ING	
EAPLOSIVES. POWOER FACTOR TOTAL LBS PRIMERS.	TETERS
ROUND. NO. HOLES OEPTH DIAM.	
MACHINE JUMRO MACHINES	FEED LENGTH

MUCK ING

SHORE MON SCHUIOT	A Z
HARDNE	4 2
SHORE	4 2
ROD PCT EST	8
STANTA STANTA	Dec 75-00
P. T. P. C.	125
ROCK PROPERTIES SEDIMENTARY: SANDSTONE COARSE GRAINED. POORLY CONSOLIDATED. ARKOSIC. WITH MINOR LAVERS OF	HIN SEAMED SILISIONE.
IDENTIFICATION WESTERN NUCLEAR SAMPLE NO	MNG-I
45,	

	PCT (-1 N0200	54.9	2	SCREEN SIZES A=ANGULAR S=SUBANGULAP R=ROUNDED P#PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPMERDIO
	61N. 31N. 21N. 1/21N. HO4 NO8 NO16 NO30 NO50 NO100 NO200		DRY SCREENED (ASTM C136). AFTER MASKING (ASTM C117). LOWER LINE. SCREENED BEFORE ORYING	NGATEO SE
٩ 2	2	:	E0 9EF	E=ELO
	NOI	0.	SCREEN	EGULAR
ž	NOSO		LINE.	I=IRR
<b>\$</b>	NO30	0.6 0.0 3.0 1.0 2.0 5.0 12.0 17.0 16.0 14.0 6.9 3.3 15.7 11.7	LOWER	C=CUBIC
e e	EENS 016	17.0	C117)	PLATY
	SCR.	12.0	HISTH	NDED P
LESS Them 1. 30	NO NO	5.0	SY.ING	R=ROU
, S21	463 -4	2.0	IFTER #	BANGULA
1.8	CENT H	1.0	1361.	IR S=SUE
	PER	15.7	(ASTH	= ANGUL
STONE.	N. 21N	9.0	REENEU	IZES /
4ED SILTSTONE.	IN.	9	DRY SC	CREEN S
THIN SEAM				
Ī.	PCT (+ IN-SI	000	UPPER	NS BET
	MOISTURE PCT(+)6 PCT IN-SIZE	10.5	SCREEN ANALYSIS: UPPER LINE	SHAPE OF FRACTIONS BETWEEN
I-9MM	MUCK DATA DRY UNIT WT PCF	35	SCREEN	SHAPE
	2			

	IN.	
TOUGHWESS INDEX	SIZE(-)2.0 IN. ANGLE INTER FRICTION OEGREES A	ž <b>12</b>
	APPARENT BULK COMESION DENSITY PSF AT PCF AT 10.6 PCT MOIST	5
FLOW INDEX 7.40	BULK DENSITY PCF AT 0.0 PCT M	
	NO T	
PLASTICITY INDEX PCT 4.93	APPAREI COMESIG PSF AT 10.6 PC	۰
PLASTIC SFULINITSSIZE(-) 0.056IN PLASTIC SFULINAGE PLASTICITY LIMIT LI INDEX PCT PCT PCT 19.97 19.94 4.93	ANGLE/REPOSE ANGLE/SLIDE ANGLE/REPOSE ANGLE/SLIDE ANGL	35
PLASTIC LIMIT PCT 19.97	ANGLE/REPOSE 10 IN UROP DEGREES AT	31
LIGUIO LIMITS PCT 24.90	LE/REPCSE N DROP REES AT PCT MOIST	
POT VOL CHANGE (-)0.056 IN.SIZE 0	SPECIF ANGLE/REPCSE GRAVITY DEGREES AT 10.1 PCT MOIST	M
0 10 d	SPECIF GRAVIT	2.71

1 CURRENT: 1 SEPT. 1972

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		POWER SYSTEM	PRIMARY SECONDARY 440V 110V		SHOTCRETE IN BAD GROUND
			<u>a</u>	91	i i
]		UTILITY LINES	AIR MATER PUMP		SET.SIZE.SHAPE
]		UTILIT	AIR W		. SET•SI
		WATER INFLOW			LATE
]		WATER	6PM 20-2S		BOLT.TYPE SIZE ROOF PLATE NONE
]			<b>£</b>	SUPPURT SYSTEM	YPE SIZE
			PRESS EXHST SIZE X 18IN	SUPPUR	NONE NONE
			EXHST		
		LATION	PRESS		SUPPLY
7		VENTILA	CFN S-7K		
]			GHADE CFN +0.SPCT 5-7K		PERSCHNEL RAIL
			SHAPE RECT	.TE%	
	KEY 46A TUNNEL DATA	بي		HAULAGE SYSTEM	MUCK Pail. 24in Gage 40lb rail
	KEY 46A TUNNE	TUNNEL	S12E 10FT X 8FT	HAUL	MUCK PAIL 40LB

Q

	THRUST.MAX/OPERATE		KLB.
	TORQUE.MAX/OPERATE	EAD CENTER	KFTLB KFTLB .
	RPM	HEAD CENTER HEAD	5 Z Z
	CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	CENTER	72 KENNAMETAL U 4.5 K PICK BITS S MOUNTED ON TWIN RIPPER HEADS
MACHINE EXCAVATION			F6-A 11 TONS
MACHINE E	MACHINE	MAKE	ALP INE MINEH

THRUST/SO FT	KLB	
GUIDANCE	TRANS IT LASER	
POWER SYSTEM	4467 ELECTRIC MOTORS	SO.4HP HEAD
MUCK SYSTEM	GATHERING ARMS 4467 ELECTRIC	14IN BELT CONV.
INCHUR PRESS		
ANCHUR	<u> </u>	

TANSIT	ASER KLU		EXPLOSIVES, POWOER FACTOR TOTAL LAS PAIMERS,	INTERIOR CUT LIFTERS
	KLB I4IN CHAIR CONV MOTORS I 14IN BELT CONV. SO.4HP MEAD TO REAR 2-20.2HP THRUST	MION	ROUNO. NO. HOLES DEPTH DIAM.	<u>.</u>
ANCHOR PRESS MUCA	KLB 141N 141N 141N	CONVENTIONAL EXCAVATION	MACHINE JUMBO MACHINES	FEED LENGTH

GUIDANCE

MUCKING

BLASTING

~	
CONKERT	
N-SVE	

		***	PCT (-)	20.1	(ASTH CI36). AFTER KASHIMG (ASTM CI17). LOWER LINE. SCREENED BEFORE DRYING A=ANGULAR S=SUBANGULAR R=HOUNDEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID	***			O IN.	
			NO200	o.	EFORE DRYING	, ã	TO'JGHNESS INDEX	n	SIZE(-)2.0 ANGLE INTER FRICTION DEGREES AT 9.0 PCT HOIS	8
SHORE NOH SCHMIOT	2		SCREENS NO30 NO50 NOIDO NOZOO	18.0 7.9	LOWER LINE. SCREENED BEFORE := CUBIC I=IRREGULAR E= ELONGAT	79.	TOYGH	0.13	TSION	Ŧ
HARDI	ž		NO50	16.0	ER LINE. BIC I=IRR		FLOW	4.00	BULK BULK DENSITY PCF AT 0.0 PCT MOIST	2
ROD SHOR	30 NA		NS NO30	16.0	17) • LOW		X-		40157	ئية قر
~ E	LESS THAN I.		WEEN SCREEN	11.0	G (ASTM CI17).		(-) 0.056I PLASTICI INDEX PCT	0.51	4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
			PER CENT BY WEIGHT BETWEEN IIN. I/ZIN. NO4 NO8	0 5.0	CI36). AFTER KASHIMG AR S=SUBANGULAR R=HOU		115\$12E AGE		SK IOE PLATE IS AT IT MOIST	0
PETA	125		CENT BY W	2.0 4.0 7.3	136) • AFT		RBERG LIMITS. SHRINKAGE LIMIT PCT	23,37	SIZE(-)2.0 ANGLE/SLIDE STEEL PLATE OLGREES AT 9.0 PCT MOI!	
PERTIES ARY: SANOSTONE COARSE POORLY CONSOLIDATED. WITH MINOR LAYERS	SEAMED SILTSTONE. CONCENTRATIONS OF EROUS MATERIAL BY SILICA.		3IN. ZIN. IIN.	0.0 0.0	• ORY SCREENED (ASTH C	. AE AE S	PLASTIC SHRINKAGE PCT INDEX INDEX PCT PCT PCT PCT PCT PCT PCT PCT PCT PCT	24.74	ANSLEATERIAL S ANSLEATEPSE IO IN URSP GEGREUS AT 9.0 PC1 MOIST	Ë
4 €	wom_		PCT(+)6 *	0.0 0.0	S E	AE	LIGUIO	55.25	ANGLE/REPOSE I IN DPOP OEGREES AT	33
ICATION			MOISTURE PCT	8.3	SCREEN ANALYSIS: UPPER LINSHAPE OF FRACTIONS BETWEEN		54 IN. 5122		IN.SIZE	
KEY IDENTIFICATION 47 WESTERN MUCLEAR SAMPLE NO	2-9NB		MUCK OATA	93	SCREEN		90 to 9	•	(-)0.75 SPFCIF GRAVITY	2.72

47A TUNNEL DATA  TUNNEL DATA  TUNNEL DATA  TUNNEL DATA  TUNNEL DATA  TUNNEL DATA  TUNNEL DATA  SIZE SHAPE GRADE CFM PRESS EXHST SIZE HP GPM SFT X RECT VARIES S-7K X IBIN DHY ZIN BIN SUPPORT SYSTEM  HAULAGE SYSTEM  WUCK  WUCK  4ZIN SCPAPER RAIL ASH HOIST		POWER	1		SHOTCRETE
VENTILATION  VENTILATION  VARIES CFM PRESS EXHST SIZE HP GPH  VARIES S-7K X 181N UHY  SUPPORT SYSTEM  PERSONNEL SUPPLY BOL: TYPE SIZE ROOF PLATE  RAIL  AIR HOIST				***	*
VENTILATION  VENTES CFM PRESS EXHST SIZE HP  VARIES S-7K X 18IN  SUPPORT SYSTEM  PERSONNEL SUPPLY BOLIVE SIZE  RAIL  AIR HOIST		UTILITY LINES	AIR WATER PU	e e	SET.SIZE.SHAPE
VENTILATION  VENTES CFM PRESS EXHST SIZE HP  VARIES S-7K X 18IN  SUPPORT SYSTEM  PERSONNEL SUPPLY BOLIVE SIZE  RAIL  AIR HOIST		INFLOW			<b>Y.ATE</b>
VENTILATION  VARIES S-7K X  VARIES S-7K X  H  PERSONNEL SUPPLY RAIL RAIL AIR HOIST		WATER	T A	ľ	ROOF
VENTILATION  VARIES S-7K X  VARIES S-7K X  H  PERSONNEL SUPPLY RAIL RAIL AIR HOIST			<u>\$</u>	T SYSTEM	VPE SIZE
VENTILATION  VARIES S-7K X  VARIES S-7K X  H  PERSONNEL SUPPLY RAIL RAIL AIR HOIST			S12E 181N	SUPPOR	BOLit
E GHADE VARIES H PERSONNEL RAIL			EXHST		
E GHADE VARIES H PERSONNEL RAIL		LATION	PRESS		SUPPLY RAIL AIR HO
LL T		VENT	CFN S-7K		
474. TUNNEL OATA TUNNEL OATA TUNNEL SIZE SHAPE SFT X RECT 'FT HAULAGE SYSTEM WUCK 42IN SCPAPER RAIL			GHADE		PERSONNEL RAIL
474 TUNNEL OF TUNNEL SIZE SFT X FFT HAULAGE S WUCK 42IN SCPI	414		SHAPE	SYSTEM	PER
	NEL NEL	TUNNEL	SIZE SFT X yFT	HAULAGE !	MUCK 42IN SCP

NCHINE NAME	1	CUTTERS.MAKE.	TYPE, UIAH, CUTTING EUGES	G EUGES	RPH TOROUE	TORQUE - MAX/OPERATE	OPERATE	THRUST, MAX/OPERATE	
						KFTLB	KFTL8	. 67	
						KFTLB	KFTLB	<b>X</b>	

SUIDANCE THRUST/SO FT	KLB
GUIDANCE	
POWER SYSTEM	
MUCK SYSTEM	
INCHOR PRESS M	
ANCHOR	KL8

CONVENTIONAL EXCAVATION		The Park High Bolder		
	ROUND.	EAPLOSIVES.	BLASTING SAFETY FINCE	MUCKING
MACHINES LE ROI	OEPTH OFT	TOTAL LBS 50. 40PCT GELEX 2 PRIMERS.	CAPS	
	CUT. BURN 5 HOLE	TRIM		
	SF/HOLE 2.5	LIFTERS		Ť,

MACHINE EXCAVATION

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PCT (-) NO200 36.4	O=SPHEROID			S	
100 NO200 12.8	REELONGATED S	OUGHNESS	0.27	SIZE(-)\$-18 ANGLE INTE FRICTION DEGREES AT I3.0 PCT HO	<b>3</b>
NO50	UBIC I=IRREGULA AI A	FLOW	ي. ش	BULK BENSITY PCF AT PCT MOIST	<b>₹</b>
	VDEO P=PLATY C=C	0.19SIN. PLASTICITY NDEX	95,	APPARENT COHESION PSF AT PCT MOIST	ď Ž
BY WEIGHT BETWEE	SUBANGULAR R=KOU! SE AI	G LIMITS.SIZE(-) HHINKAGE IMIT CT	13.94 I.	-) 0.185 IN NGLE/SLIDE TEEL PLATE EGREES AT .5 PCT HOIST	<b>%</b>
31N. 21N. 11N. 1/		PLASTIC S LIMIT L	16.19	FERIAL SIZE FPOSE ROP AT MOIST I	33
PCT (+)6 • IA.SIZE 6IN.		LIGUID PCT PCT	17.75		36
MUCK DATA DOY UNIT MOISTURE WI PCF PCT 91 18.5	SHAPE OF FRACTION	POT VOL CHANGE (-) 0.06S IN.SIZE	0	(-)0.1851N.SIZE SPECIF AN GRAVITY DE	2.86
	DATA UNIT MOISTURE PCT(+)6 ************************************	DATA  UNIT HOISTURE PCT(+)6 ************************************	DATA UNIT MOISTURE PCT(+)6	DATA UNIT MOISTURE PCT(+)6	DATA UNIT MOISTURE PCT(+)6 ************************************

	<u>د</u>		
STEM	SECOND 480		
POWER SYSTEM	PRIMARY SECONDARY	eke .	SHOTCRETE
		ij	151
INES	AIR WATER PUMP		SET.SIZE.SHAPE CONTINUOUS PRECAST CONCRETE BIN OR 101N THICK X 4FT - 4 SEGMENT
UTILITY LINES	WATE	ŧ <sub>o</sub>	SIZE.
5	AIR		SE CONT
MELOW	۴.		LATE
WATER INFLOW	6P# 200	¢ .;	BOLT.TYPE SIZE ROOF PLATE
4		STEM	\$12E
	<u>+</u>	SUPPORT SYSTEM	TYPE
	3618	SUPP	BOLT
	EX:15T		
/ENTILATION	PRESS EXMST SIZE FACE X 36IN		SUPPLY
VENT	CFN 20K		
	GRADE +0.25PCT		PERSONNEL RAIL
	SHAPE	SYSTEM	
TUNNEL	SIZE	HAULAGE	MUCK RAIL

KEY 48A TUNNEL DATA

MODEL WY CENTER INTERIOR GAGE		•
	GAGE HEAD, CENTER HEAD	CENTER
ROBBINS 2215 285 HYDRAULIC OPERATED RIPPER 1001H	1001H KFTLB	KFTLB KLB 7000

46 199			
THRUST/SQ FT		KLB	
GUIDANCE			
POWER SYSTEM	AL CAROLE		
HUCK SYSTEM	שמרעבו וח פו	CONVEYOR TO	OFAD
ANCHOR FRESS		7.B	

		BLA	
\$   P1 			
LASER KLU	. ; 5 ¥ §.	EXPLOSIVES. POWDER FACTOM TOTAL LBS	PRIMERS. TRIM INTERIOR
RUCKET TO 6FT HYDRAULIC CONVEYOR TO REAR	EXCAVATION	ROUND, NO. HOLES DEPTH	CUI.
۳L8	CONVENTIONAL EXCAVATION	HACHINE JUMBO HACHINES	· FEED LENGTM

	PCT (-)	19.0		SPHEROII			ži t	40
	. 00200		E DRYING	ATEO SP			SIZE(-)I.0 I ANGLE INTER FRICTION DEGREES AT IS PCT MOIST	71
MA MIOT	NO 100	10.5	VEO BEFO	E=ELONG	TOUGHNESS	19.0	SIZE( ANGL FRIC DEGE	7.2
RONESS.		9.5	SCREE!	IRREGULAF S.I			IIY AT PCT MOIST	¥.
w w	30 NO50	1.5	LOWER LINE. SCREENED BEFORE DRYING	CUBIC I=1	FLOW	7.6	BULK OENS PCF	
ROO SHOO SHOO SHOO SHOO SHOO SHOO SHOO S	REENS	9.0		S=SUBANGULAR R=ROUNOEO P=PLATY C=CUBIC I=IRREGULAR E=ELONGATEO SP=SPHEROII SI SI SI SI SI	IN		APPARENT COMESION PSF AT PCT HOIST	NA A
~ E	BETWEEN SCREENS. NOS NOIG	9.0	S CASTH C	JUNDEO PE	PLASTIC SHRINKAGE PLASTICITY PLASTIC THIT LIMIT PCT	2.4	APPA COME PSF	
		6 0.5	R WASHING	ULAR R=KI	15\$12E (		INATE ATE HOIST	
ORY MT PCF	.PER CENT BY WEIGH IIN. I/2IN. NO4	4 34.6	6) • AFTE	S=SUBANG	ERG LIMI SHRINKA LIMIT PCI	21.5	SIZE(+)1.0 ANGLE/SLIDE STEEL PLATE OEGNES AT IS.1 PCT HOIS	30
A T 50 •		8.6 I4.4	(ASTH CI3	A=ANGULAR RS RS	ATTERB		215	
ROCK PROPERTIES SECIMENTARY: SANOSTONE AND BIOTITE RICH SILTSTUNE. POORLY TO WELL CONSOLIOATEO. POORLY TO WELL SOMTEO.	JIN. ZIN.	0.0	CREENED		PLAST LIMIT PCT	26.8	ANGLE/KEPOSE 10 IN BROP 0EGREES AT 15.1 PC1 MOIST	36
ROCK PROPERTIES SEGIMENTARY: SA BIOTITE RICH POORLY TO WELL POORLY TO WELL	6IN 3	0.0	E. ORY S	SCREEN SIZES	LIQUIO LIMITS PCT	v		
ROCK PR SECIMEN BIOTITE POORLY POORLY	PCT(+)6 IN-SIZE	0.01	UPPER LINE. ONY SCREENEU (ASTM CI36). AFTER WASHING (ASTM CII7).	NS BETWEEN		31.	ANGLE/REPOSE 1 IN OPOP OEGREES AT 15.1 PCT MOIST	36
I CATION INDO NO	MOI STURE PCT	17.5	SCHEFN ANALYSIS:	SHAPE OF FRACTIONS BETWEEN	POT VOL CHANGE (-)0.056 IN.SIZE			
IOENTIFICATION SAN FERNANDO SAMPLE NO SF-2	HUCK OATA DRY UNIT WT PCF	80	SCHEFN A	SHAPE 0	POT VOL	•	(-)0.75 IN.SIZE SPECIF GRAVITY	3.02
XEY	30 x							

	(*) 	POWER SYSTEM	PRIMARY SECONOAR	in the second se	SMOTCRETE
			-E	i i	2.8
		UTILITY LINES	AIR WATER PUMP SO	*45- 2#	SET.SIZE.SHAPE CONTINUOUS PRECAST CONCRETE BIN OR 10IN THICK X 4FT - 4 SEGMENT
		UTILI	AIR		SET SET SET SET SET SET SET SET SET SET
]		WATER INFLOW		÷	PLATE.
		WATER	6PM 00	k	BOLT.TYPE SIZE ROOF PLATE
			÷	SUPPORT SYSTEM	YPE SIZE
			PRESS EXHST SIZE FACE X 36IN	SUPPOR	60LT•T
		7	S EXHST		÷.
		VENTILATION			SUPPLY
		VENT	CFH 20K		
			GRA0E CFM +0.25PCT 20K		PERSONNEL RAIL
	414		SHAPE	SYSTEM	
	KEY 498 TUNNEL DATA	TUNNEL	\$12E 21FT	HAULAGE SYSTEM	MUCK

		CUTTERS.MAKE.TYPE.UIAM.CUTTING EDGES	RPM	TORQUE.MAX/OPERATE	THRUST . MAX/OPER
	¥1 285	CENTER INTERIOR GAGE HYDRAULTC OPERATED RIDDER LOGIN	HEAD.CENTER HEAD	HEAD CENTER	
RIPPER TO SHIELO	LONS			KFTLB KFTLB	1

THPUST/SO FT	7	
GUIDANCE	1 + 3C K	r
POWER SYSTEM	TI OF WOLL	
MUCK SYSTEM	CONVEYOR TO	REAR
PRESS		
ANCHOR	KLB	

, valion	ROUND. NO. HOLES FOWDER F OFFITH TOTAL LB
CONVENTIONAL EXCAVATION	HACHINE R JUMBO N

BLASTING MUCKING	g., e		·4
EXPLOSIVES. POWOEM FACTOR	TOTAL LBS	INTERIOR	Lifters
ROUND.	OEPTH OIAM.	cut.	

FEED LENGTH

GUIDANCE

MACHINE EXCAVATION

<u></u>	PCT (-) NO200 29.6	SPHERO IC				ž į	
NA NA	SCREENS	(ASTM CI36). AFTER WASHING (ASTM CI17). LOWER LINE. SCREENEO BEFORE DRYING A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC  =IRREGULAR E=ELONGATED SP=SPHEROID		TOUGHNESS	26.0	SIZE(-)2.0 IN ANGLE INTER FRICTION OEGREES AT 10.9 PCT MOIST	\$ <b>50</b> \$ 100 \$ 50 \$ 50 \$ 50 \$ 50 \$ 50 \$ 50 \$ 5
RONESS.	0. 0. 0.	SCREE				IITY AT PCT HOIST	2
, , , , , , , , , , , , , , , , , , ,	00 NOS	WER LINE	,	FLOW	3.60	BULK OENS PCF	щ
855	ENS	117)· LG	4	IN		, (SI O)	37
	EEN SCREE	AFTER WASHING (ASTM CII7). BANGULAR R=ROUNDED P=PLATY	<	PLASTIC SHRINKAGE PLASTICITY LINIT LIMIT PCT PCT	3,33	APPARENT COHESION PSF AT IO.9 PCT	HE
COMPR STRNIH RPSI II	6HT BETWE	WASHING	<	SSIZE (		IN	
DRY 144	7.21N. WEIG	SUBANGU	4	RG LIMIT SHRINKAGI LIMIT PCT	19.12	SIZE(-)2.00 ANGLE/SLIDE STEEL PLATE DEGREES AT 12.7 PCT HOIS	3
ξ. •	IIN. I. 1. 5.2	STM CI36	<b>I</b>	ATTERBE		L SIZE	
ROCK PROPERTIES SEDIMENTARY: MUDSTONE, DARK GRAY, FINE GKAINED, MASSIVE,	31N. ZIN. IIN. I/ZIN. NO4 NO8 5.9 I.9 5.2 28.9 0.3 I	긢	Id	PLASTIC LIMIT PCT	24.97	ANGLE/REPOSE ANGLE/REPOSE 10 IN UROP DEGREES AT 12.7 PCT HOIST	82
DPERTIES TARY: MUD INE GKAIN	61N. 31 20.0	E. DRY SCREEN SCREEN SIZES	<b>a</b>	010 1TS	90	1 12	
ROCK PRI SEDIMENI GRAY, F.I	PCT(+)6 IN-SIZE 0.0 46.7	ANALYSIS: UPPER LINE.	P.E.	E LIGUID LIMITS PCT	28.30	ANGLE/REPUSE I IN OROP DEGREES AT 12.7 PCT MOIS	53
CAT 10N	MOISTURE PCT 9.4	SCREEN ANALYSIS: SHAPE OF FRACTIO		POT VOL CHANGE (-)0.056 IN.SIZE			
KEY IDENTIFICATION 50 KERR-MCGE SAMPLE NO KM-1	MUCK DATA DRY UNIT WI PCF	SCREEN A		POT VOL (-) 0.056	•	(-)0.75 IN.SIZE SPECIF GPAVITY	2.87

CURRENT: 1 SEPT. 1972

KH-1

0

		STEM	PRIMARY SECONDARY		
		POWER SYSTEM	ARY		m ,
		POWE	PRIM		SHOTCRETE
					SHOT
		S	РИМР		m &
		LINE	ER		STEEL 3FT
		UTILITY LINES	AIR WATER PUMP		SET.SIZE.SHAPE 4IN WF STEEL SETS AT 3FT OR 6FT
			$\mathcal{L}_{\mathbf{w}}$		
		INFL	• "*,		LATE
		WATER INFLOW.	GPN OMY	*. d	BOLT.TYPE SIZE ROOF PLATE
				STEN	SIZE
			₹ %	RT SY	TYPE
			S12E 241N	SUPPORT SYSTEM	BOLT.
			PRESS EXHST SIZE FACE VENT 24IN		
		110N	RESS I		SUPPLY
		VENTILATION			N &
		, Ç	S. Y.		
			GRADE +0.5PCT		ONNEL
			9 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 +		PERSONNEL RAIL
			SHAPE	TEM	GAGE
	OATA			SYS	S6IN
KEY	50A TUNNEL DATA	TUNNEL	S12E 10FT X 5FT	HAULAGE SYSTEM	PUCK RAIL• 36IN GAGE 45LB RAIL

	TKRUST . MAX/OPERAT		. 8, tX	KL8	
	TORQUE.NAX/OPERATE	CENTER	KFTLB	KF1L8	
	TORQUE, NA	HEAD	KFTLB	KFTLB	
	RPM	HEAD CENTER HEAD	2		
	ė EDGES	GAGE	TIP WOOM 'CIT		
	E.DIAM.CUTTIN	INTERIOR	HEAUS		
le	CUTTERS.NAKE.TYPE.DIAM.CUTTING EDGES	CENTER INTERIOR GAGE	ON TWIS RIPPER		
			TONS		
CAVATION		MODEL	4 1 0 L		
MACHINE EXCAVATION	MACHINE	MAKE	RINER		

FT			
THRUST/SO FT		RL:	
GUIDANCE	TRANSIT	LASER	
POWER SYSTEM	ELECTHIC MOTORS	50.4HP HEAD LASER	2-20.4HP THRUST
MUCK SYSTEM	GATHERING ARMS	14IN FLIGHT	CONVETOR
PRESS			
ANCHOR		KLB ,	

CONVENTIONAL EXCAVATION	AVATION				
MACHINE	ROUND.	EXPLOSIVES	BLASTING	MUCKING	6010
JUMBO	NO. HOLES	POWDER FACTOR			
TACHINE S	DIAM.	PRINERS.			
	cur.	TRIK			
FEED LENGTH		INTERIOR			
		LIFTERS			

APPENDIX C
SYSTEM DATA SHEETS

			E -
<u>Identification</u>	Page Page	Identification	Page
NAST-1	C-1, C-2	5-1	C-51, C-52
NAST-2	C-3, C-4	7-2	C-53, C-54
NAST-3	C-5, C-6	11-3	C-55, C-56
NAST-4	C-7, C-8	11-4	C-57, C-58
GA-1	C-9, C-10	72-1	C-59, C-60
<b>H-1</b>	C-11, C-12	MSU-1	C-61, C-62
H-2	C-13, C-14	MSU-2	C-63, C-64
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LK-2	C-17, C-18	LAW-3	C-67, C-68
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LK-6	C-21, C-22	MIL-1	C-71, C-72
LK-7	C-23, C-24	MIL-2	C-73, C-74
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LK-3	C-29, C-30	EVG-2	C-79, C-80
LK-4	C-31, C-32	JAY-1	C-81, C-82
MB-1	C-33, C-34	LAY-2	C-83, C-84
MB-3	C-35, C-36	NAV-1	C-85, C-86
ST-1	C-37, C-38	NAV-2	C-87, C-88
CR-1	C-39, C-40	RO-1	C-89, C-90
. • HS-1	C-41, C-42	WNG-1	C-91, C-92
NY-I	C-43, C-44	WNG-2	C-93, C-94
NY-2	C-45, C-46	SF-1	C-95, C-96
QL-I	C-47, C-48	SF-2	C-97, C-98
MB-2	C-49, C-50	KM-1	C-99, C-100
			V <sub>2</sub>

APPENDIX C
SYSTEM DATA SHEETS

Lithology: Igneous, granite, gray, medium to fine grained, moderately to slightly fractured and jointed, 10 to 20% quartz, 50 to 60% feld#par, balance dark minerals.

Uniaxial Compressive Strength: 18 KPSI.

RQD: (Estimated) 90%.
Dry Unit Weight: 167 PCF.

Ground Water: Minor, primarily from fault zones.

Hardness: NA

## TUNNEL DATA:

Size: 9' 9" diameter. Grade: (+) 0.22%.

Ventilation System: 10 KCFM, exhaust, 22" pipe to rear of conveyor,

16" to face.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 5 to 20 gpm. Power System: 4160/480V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage,

70# rail.

Support System: 4" ring and half sets, at 4', 3' and 2' centers in bad ground,

13" wide x 10' - 16 gage plates secured by 4-1" x 7' grouted bolts as

required.

## **EXCAVATION DATA:**

Machine: Wirth Erkelenz, Hardrock Model. Weight: 67 tons.

Cutters: 25 Hughes Tool/Wirth Tungsten Carbide Button. Gage: 6-11 1/2" TCB roller. Interior: 15-11 1/2" TCB roller. Center: 2-11 1/2" roller

and 2-11 1/2" TCB Cone. Rotation: Head, 8 1/2 RPM

Torque: 150 K ft. # max., 110 K ft. # operating

Thrust: 290 K lbs.

Muck System: Bucket from face, 22" belt conveyor to rear.

Power System: 3-200 HP electric motor driven hydraulic pumps driving

hydraulic motors.

Guidance System: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NAST-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.065": 0

Spec. Gravity, Material Size(-) 0.50": 2.69

ATTERBERG LIMITS, MATERIAL SIZE (-)0.185 IN.

Liquid Limit 14.50% Plasticity Index 0.50%

Plastic Limit 14.00 % Toughness Index 0.16 % Shrinkage Limit 13.50 % Flow Index 3.0 %

MATERIAL SIZE (-) 0.50 IN.

Angle/Repose 1" Drop

9.0 % Moisture, 370

Angle Slide Steel Plate

9.0 % Moisture, 410

Apparent Cohesion PSF

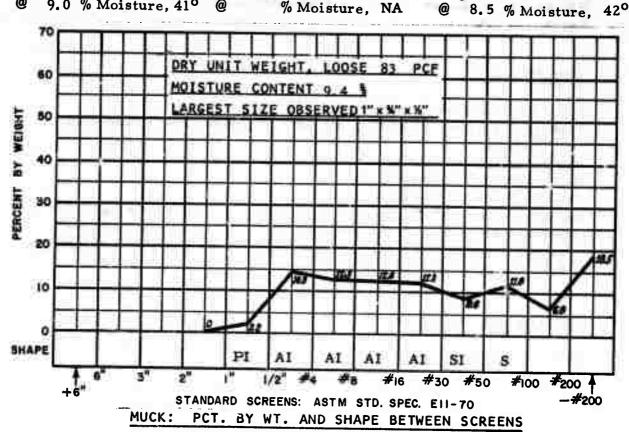
@ % Moisture, NA
Bulk Density PCF

Angle/Repose 10" Drop

9.0 % Moisture, 36°

Angle Internal Friction

8.5 % Moisture, 42°



### SUMMARY

Rock Class: Igneous: Granite, moderately to slightly fractured and jointed. Medium to fine grained. High strength. RQD (Est.) 90%. DUW: 167 PCF. Ground water: Minor. Hardness: NA

System Class: TBM, Wirth Erkelenz, Hardrock, 9'9" dia. 25 Hughes Tool/Wirth TCB roller and cone cutters. RPM: 8-1/2, 110 K ft # Torque, 290 K# Thrust. Mucking: Buckets to belt. Haulage: Rail. Support: Steel ring and half sets, roofplates and rock bolts.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NAST-1 Sheet 2

Lithology: Igneous, granite, gray, medium to fine grained, moderately to slightly fractured and jointed, 10% to 20% quartz, 50% to 60% feldspar, balance dark minerals.

Uniaxial Compressive Strength: 18 KPSI.

RQD: (Estimated) 90%. Dry Unit Weight: 167 PCF.

Ground Water: Minor, primarily from fault zones.

Hardness: NA

## TUNNEL DATA:

Size: 9'9" diameter. Grade: (+) 0.22%.

Ventilation System: 10 KCFM, exhaust, 22" pipe to rear of conveyor,

16" to face.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 5 to 20 gpm. Power System: 4160/480V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage 70# rail.

Support System: 4" ring and half sets, at 4', 3' and 2' centers in bad

ground (approximately 650'), 13" wide x 10' - 16 gage plates secured by 4-1" x 7' grouted bolts as required, (approximately 1200').

### **EXCAVATION DATA:**

Machine: Wirth Erkelenz, Hardrock Model. Weight 67 tons.

Cutters: 25 Hughes Tool/Wirth Tungsten Carbide Button. Gage: 6-11 1/2" TCB roller. Interior: 15-11 1/2" TCB roller. Center: 2-11 1/2" roller and 2-11 1/2" TCB cone.

Rotation: 8 1/2 RPM

Torque: 150 K ft # max., 100 K ft. # operating.

Thrust: 290 K lbs

Muck System: Bucket from face, 22" belt conveyor to rear.

Power System: 3-200 HP electric motor driven hydraulic pumps driving

hydraulic motors and cylinders.

Guidance System: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NAST-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056": 0

Spec. Gravity, Material

Size (-) 0.50": 2.66

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 19.5 % Plasticity Index 1.3 % Plastic Limit 18.2% Toughness Index 0.28%

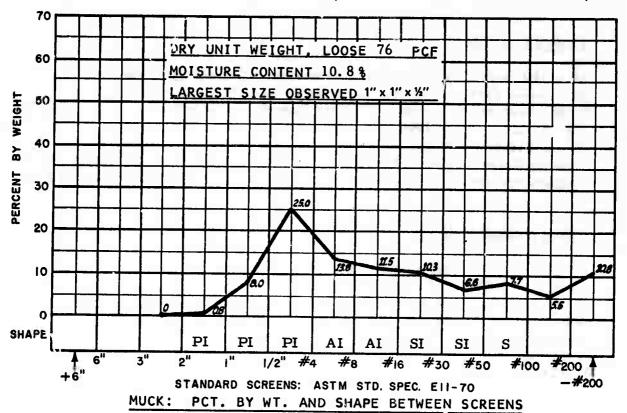
Shrinkage Limit 17.9 % Flow Index 4.6 %

MATERIAL SIZE (-)1.0 IN.

Angle/Repose 1" Drop 8.7 % Moisture, 380 Angle Slide Steel Plate 8.7 % Moisture, 490

Apparent Cohesion PSF % Moisture, NA Bulk Density PCF % Moisture, NA

Angle/Repose 10" Drop 8.7 % Moisture, 38° Angle Internal Friction 8.5 % Moisture, 31°



SUMMARY

Rock Class: Igneous: Granite, medium to fine grained, moderately to slightly fractured and jointed. High strength. RQD: (Est.) 90%. DUW: 167 PCF. Ground water: Minor. Hardness: NA.

System Class: TBM, Wirth Erkelenz Hardrock. 9' 9" dia. 25 Hughes Tool/ Wirth TCB roller and tricone cutters. RPM: 8-1/2, 100 K ft # Torque, 290 K# Thrust. Mucking: Buckets to belt. Haulage: Rail. Support: 4" ring and half sets, roof plates and rock bolts.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NAST-2 Sheet 2

Lithology: Igneous, biotitic granite, fine grained, with major quartz and minor feldspar and dark mineral contents.

Uniaxial Compressive Strength: 13 KPSI.

ROD: (Estimated) 90%.

Dry Unit Weight: 152 PCF.

Ground Water: Minor, from fault zones.

Hardness: NA

### TUNNEL DATA:

Size: 10' high x 16' wide x 8', alcove from 9'-9" diameter tunnel.

Ventilation System: 10 KCFM, exhaust, 22" pipe.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 5-10 GPM.

Power System: Not applicable.

Haulage System: Muck, personnel, supplies by rail cars, 36" Gage, 70# rail. Support System: 1" x 7' grouted rock bolts and 13" x 10'-16 gage room plates.

### EXCAVATION DATA:

Conventional Rail Haulage System. Drilling: 2-S53F, 4' feed, jack legs.

Drill Round: 72 holes, 1 3/4" diameter, 9' av. depth, double V-cut.

Explosives: 300# Gelox #2-60%. Powder Factor, 6.3#/CY.

Blasting: Electrical, zero and 7 regular delays.

Mucking: Diesel front end loader, 1/2 CY.

Guidance: Not applicable.

24 14 16 16

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056" : 0

Spec. Gravity, Material Size(-)0.75": 2.65

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 19.50%

Plastic Limit 17.41 % Plasticity Index 2.09 % Toughness Index 0.51 %

Shrinkage Limit 17.13 % Flow Index 4.10 %

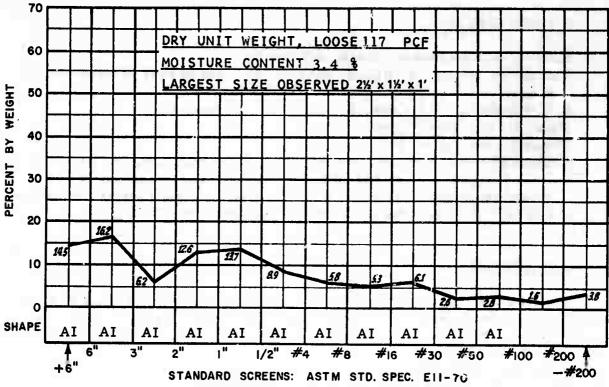
MATERIAL SIZE (-) 2.0 IN.

0.0 % Moisture, 91.2

Angle/Repose 1" Drop Angle Slide Steel Plate % Moisture, 31° @ @ 2.8

Apparent Cohesion PSF @ 2.8 % Moisture, 39° @ 3.0 % Moisture, 80 Bulk Density PCF

Angle/Repose 10" Drop @ 2.8 % Moisture, 36° Angle Internal Friction @ 3.0 % Moisture, 38°



MUCK: CCT. BY WT. AND SHAPE BETWEEN SCREENS

### SUMMARY

Rock Class: Igneous: Granite, biotitic, fine grained. Medium strength. RQD (Est.) 90%. DUW: 152 PCF. Ground water: Minor. Hardness: NA.

System Class: Conventional Rail. 10' high x 16' wide x 8' alcove. Two jack leg drills, 72-9' holes, double V-cut. PF 6.3#/CY. Mucking: Diesel front end loader, 1/2 CY. Haulage: Rail. Support: Grouted rock bolts and roof plates.

**MDN STUDY** 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NAST-3 Sheet 2

Lithology: Igneous, granite, fine grained, moderately fractured, major quartz and minor feldspar and dark mineral contents.

Uniaxial Compressive Strength: 24 KPSI.

RQD: (Estimated) 90%. Dry Unit Weight: 160 PCF.

Ground Water: Minor, primarily from fault zones.

Hardness: NA

## TUNNEL DATA:

Size: 9'-10" diameter. Grade: (+) 0.22%.

Ventilation System: 10 KCFM, exhaust, 22" pipe to rear of conveyor, 16"

to face.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 5 to 20 gpm. Power System: 4160/480V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage 70# rail.

Support System: 4" ring and half sets, at 4', 3' and 2' centers in bad ground (approximately 650'), 13" wide x 10' - 16 gage plates secured by 4-1" x 7' grouted bolts as required, (approximately 1200').

### **EXCAVATION DATA:**

Machine: Wirth Erkelenz, Hardrock Model (Modified)\*. Weight 67 tons. Cutters: 29 Hughes Tool Tungsten Carbide Button. Gage: 6-11 1/2" TCB roller. Interior: 19-11 1/2" TCB roller. Center: 2-11 1/2" roller and 2-11 1/2" TCB cone.

Rotation: 8 1/2 RPM.

Torque: 150 K ft. # max., 125 K ft. # operating

Thrust: 630 K lbs.

Muck System: Bucket from face, 22" belt conveyor to rear.

Power System: 3-200 HP electric motor driven hydraulic pumps driving

hydraulic motors and cylinders.

Guidance System: Laser.

\*Modified by replacement of original by a Hughes Tool Co. cutting head and cutters.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NAST-4
Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056 : 0

Spec. Gravity, Material Size (-) 0.75: 2.64

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

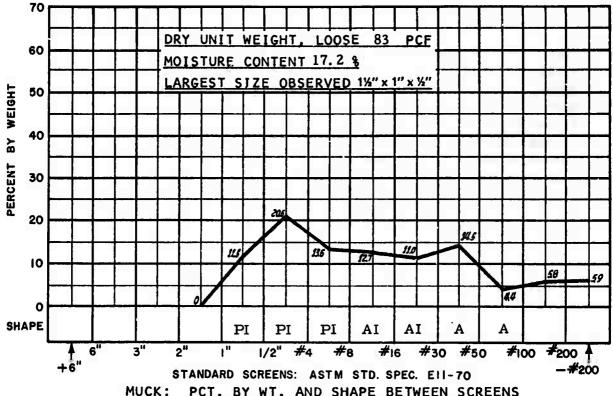
Liquid Limit 19.20% Plasticity Index 0.23 %

Plastic Limit 18.97% Toughness Index 0.06 % Shrinkage Limit 17.50% Flow Index 3.40 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop 6.9 % Moisture, 390 Angle Slide Steel Plate 6.9 % Moisture, 400

Apparent Cohesion PSF @ 7.1 % Moisture, 0 Bulk Density PCF 0.0 % Moisture, 91 Angle/Repose 10" Drop @ 6.9 % Moisture, 34° Angle Internal Friction @ 7.1 % Moisture, 33°



PCT. BY WT. AND SHAPE BETWEEN SCREENS

### SUMMARY

Rock Class: Igneous: Granite, fine grained, moderately fractured. High strength. RQD (Est.) 90%. DUW: 160 PCF. Ground water: Minor. Hardness: NA

System Class: TBM, Wirth Erkelenz, Hardrock, with Hughes Tool head, 9' 10" dia. 29 Hughes Tool TCB roller and cone cutters. RPM: 8 1/2. 125 K ft # torque, 630 K# thrust. Mucking: Buckets to belt. Haulage: Rail. Support: 4" ring and half sets, roof plates and rock bolts.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NAST-4 Sheet 2

Lithology: Igneous, granite, massive, major feldspar and quartz, minor dark mineral content.

Uniaxial Compressive Strength: 35 KPSI

RQD: (Estimated) 96% Dry Unit Weight: 161 PCF

Ground Water: Minor, through fractures.

Hardness: NA

## TUNNEL DATA:

Size: 10' x 10' Horse shoe. Grade (-) 0.22% Ventilation System: 8 KCFM, exhaust, 22" pipe.

Utility System: 6" air line, 2" water line

Water Inflow: 5-10 gpm.

Power System: 110V. lighting

Haulage System: Muck and supplies: Eimco 912 diesel.

Support System: 4" WF steel sets @ 4' in 180' approx. at portal end; 1" x 7'

grouted rock bolts for approx. 35'.

## **EXCAVATION DATA:**

Conventional Trackless System.

Drilling: Crawler Jumbo, 2-D93 Drifters, 10' feeds.
Drill Round: 48-1 3/4" holes, double V cut, 8' depth.
Explosives: 175# Gelex #2-70%. Powder factor, 6.1#/CY.

Blasting: Electrical, regular delays, zero through #10.

Mucking System: Eimco 912 diesel, front end loader.

Guidance: Transit lines.

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.59

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 16.20% Plasticity Index 0.42% Plastic Limit 15.78 % Toughness Index 0.14 %

Shrinkage Limit 13.67% Flow Index 3.00 %

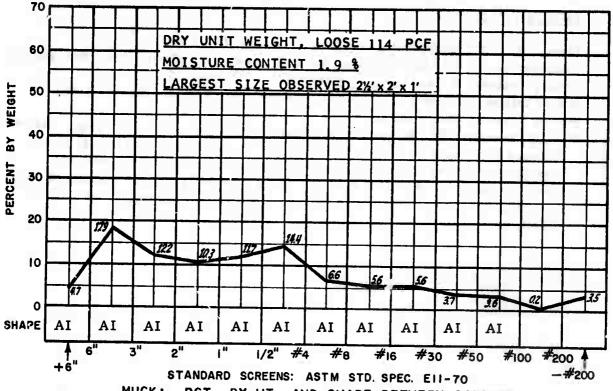
MATERIAL SIZE (-) 2.0 IN.

0.0 % Moisture, 106

Angle/Repose 1" Drop Ag
@ 0.9 % Moisture, 390 @
Angle Slide Steel Plate Bg
@ 0.9 % Moisture, 340 @

Apparent Cohesion PSF @ 0.9 % Moisture, 215 Bulk Density PCF

Angle/Repose 10" Drop @ 0.9 % Moisture, 36° Angle Internal Friction @ 0.9 % Moisture, 46°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Igneous: Granite, massive, minor dark minerals. Very high strength. RQD (Est.) 96%. DUW: 161 PCF. Ground water: Minor. Hardness: NA

System Class: Conventional Trackless. 10' x 10' arch. Two machine jumbo, 48-8' holes, V-cut. PF 6.1 #/CY. Front end loader mucking and haulage. Support: Steel sets at 4', 25%, occasional rock bolts in 730'.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. GA-1 Sheet 2

Lithology: Igneous, granite, gray, fine grained, moderately jointed with 1.5' to 2' bands of light tan pegmatite and laminated granite gneiss.

Uniaxial Compressive Strength: 32 KPSI.

RQD: (Estimated) 80%. Dry Unit Weight: 162 PCF.

Ground Water: Formations generally dry.

Hardness: NA

## TUNNEL DATA:

Size: 10' x 10'. Modified Horseshoe. Grade: (+) 1/4%

Ventilation: 15 KCFM, exhaust, 26" dia. pipe, 125 HP at 7200' from portal.

Utility System: 8" air line, 4" water line, 10" pump line.

Water Inflow: 20 GPM. (As much as 400 GPM in occasional pockets)

Power System: 4160/440V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage, 75# rail. Three-15T. Goodman locomotives; 2 trains of 11 to 13 cars @ 4.8 CY. Canton car transfer at 50' to 250' from face, passing tracks @1500'.

Support System: 4" WF sets @ 4', 3' and 2' for 23%, 1" x 7' grouted bolts for 17%, Shotcrete: 500 psi @ 18 hrs., 3750 psi @ 28 days, for 16% of 7200'.

## EXCAVATION DATA

Conventional Rail System.

Drilling: Rail mounted hydrojib jumbo, 4-CF99, & 1-CF133 drifters, 12' feed.

Drill Round: 38 holes, 1-5" center hole and 37 at 1 3/4" dia. Spiral Burn Cut. 10 1/2' depth.

Explosives: 183 lbs. Gelex #2-75% x 1-1/2" dia., and 20 lbs. Smooth-tex  $70\% \times 7/8$ " dia. in upper perimeter holes. Powder factor: 5 1/2#/CY.

Blasting: Electrical, regular delays zero through 10.

Mucking: EIMCO #25, rail, air operated.

Guidance: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. H-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056":

Spec. Gravity, Material Size(-)0.75" : 2.70

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.0% Plasticity Index 1.0 %

Plastic Limit 17.0 % Toughness Index 0.23 % Shrinkage Limit 13.4 % 4.4 % Flow Index

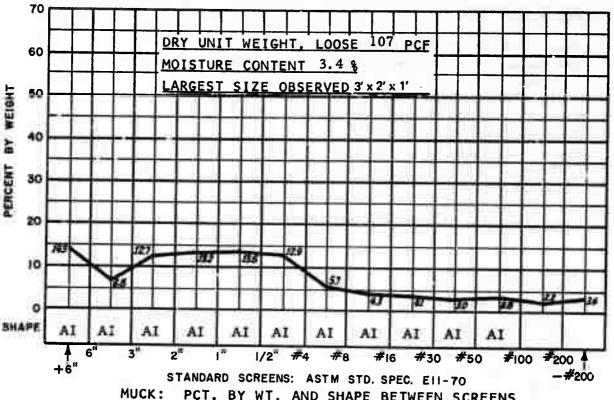
MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop 1.3 % Moisture, 40° Angle Slide Steel Plate 1.3 % Moisture, 32°

Apparent Cohesion PSF % Moisture, NA

Bulk Density PCF % Moisture, NA

Angle/Repose 10" Drop 1.3 % Moisture. Angle Internal Friction 2.2 % Moisture, 440



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Igneous: Granite, fine grained, with 1.5' to 2' bands of pegmatite and laminated granite gneiss. High strength. RQD (Est.) 80%. DUW: 162 PCF. Ground water: Minor. Hardness: NA.

System Class: Conventional Rail. 10' x 10' arch. Five machine jumbo, 38 10-1/2' holes, burn cut. PF 5.5#/CY. Overhead loader mucking, rail haulage. Support: Steel sets at 2' to 4', 23%, rock bolts 17%, shotcrete 16%, in 7200'.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. H-1 Sheet 2

Lithology: Igneous, granite, gray, gneissic, moderately jointed.

Uniaxial Compressive Strength: 39 KPSI

RQD: (Estimated) 80% Dry Unit Weighh: 164 PCF

Ground Water: Generally dry - occasional flows through fractures

Hardness: NA

## TUNNEL DATA:

Size: 10' x 10' modified horseshoe. Grade: (+) 1/4%

Ventilation System: 8 KCFM exhaust, 26" pipe, 150 HP at 10,000 from portal.

Utility System: 8" air line, 4" water line, 10" pump line

Water Inflow 20-400 GPM, normal 135 GPM

Power System: 4160/480/240V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage, 75# rail. Three-15T. Goodman locomotives, 3 trains of 5 to 7 cars @ 4.8 cy. Canton car transfers at 50' to 250' from face, passing tracks @ 1500' to 2500'.

Support System: Minor rock bolt support for last 2500'.

### **EXCAVATION DATA:**

Conventional Rail System

Drilling: 4 boom Hydojib jumbo, 4-CF99 + 1-CF133 drifters, 12' contin. feed.

Drill Round: 36-40 holes, 1 3/4" diameter, 11' deep, spiral burn cut with 5" center hole.

Explosives: 200 lbs. 75% Gelex #2, 25 lbs. 30% Dupont 7/8" x 24" in back holes.

Blasting: Electrical, regular delays 0-10, Powder factor 5.6#/CY.

Mucking: EIMCO #25, rail, air operated

Guidance: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET
MDN

Ident. No. H-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056":

Spec. Gravity, Material Size (-)0.75" : 2.60

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.10% Plasticity Index 0.15 % Plastic Limit 17.95% Toughness Index 0.04 %

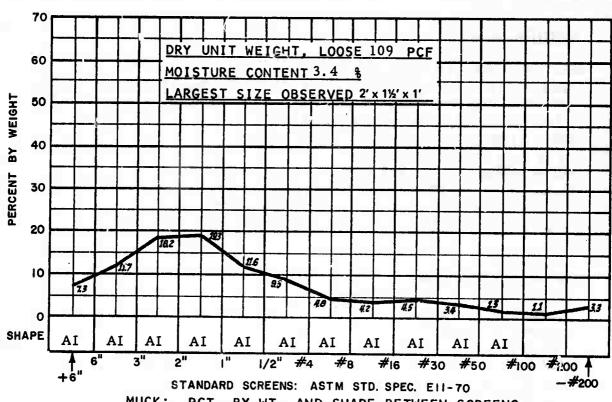
Shrinkage Limit 11.00 % Flow Index 3.20 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop 3.8 % Moisture, 380 Angle Slide Steel Plate 3.8 % Moisture, 38°

Apparent Cohesion PSF @ 2.6 % Moisture, 30 Bulk Density PCF @ 0.0 % Moisture, 105

Angle/Repose 10" Drop @ 3.8 % Moisture, 350 Angle Internal Friction @ 2.6 % Moisture, 44°



PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Igneous: Granite, gneissic, moderately jointed. Very high strength. RQD (Est.) 80%. DUW: 164 PCF. Ground water: Minor. Hardness: NA

System Class: Conventional Rail. 10' x 10' arch. Five machine jumbo, 36 to 40 - 11' holes, burn cut. PF 5.6#/CY. Overhead loader mucking - rail haulage. Support: occasional rock bolts 7200' to 10,000'.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. H-2 Sheet 2

Lithology: Igneous, biotitic quartz monzonite, fine to medium grained porphyry.

Uniaxial Compressive Strength: 25 KPSI

RQD: (Estimated) 83% Dry Unit Weight: 162 PCF. Ground Water: None apparent

Hardness: NA

## TUNNEL DATA:

Size: 18' wide x 16' high, arched back. Grade: (+) 5 1/2%.

Ventilation System: 76 KCFM, pressure in heading, 48" pipe and tubing. Underground fans 48", 150 HP, 2 stage. Exhaust in return airway to 3-54", 150 HF, 2 stage, surface fans.

Utility System: 6" compressed air, 2" water.

Water Inflow: None apparent.

Power System: 4160/220V for fans, 110 volt lighting.

Haulage System: Wagner ST8 Scooptram to raise, chute loaded into rail

mounted skip. Personnel and supplies by diesel truck.

Support System: 13 1/2" x 9' roof plates, 6' x 3/4" rock bolts @ 4'.

# **EXCAVATION DATA:**

Conventional Trackless System

Drilling: Gardner-Denver 3 boom jumbo, 1 PR123 and 2 DH 123 drifters, 12' feeds.

Drill Round: 47 holes, 1 3/4" diameter, including 6 hole burn cut, and 1 center hole, 4" diameter, all 10 1/2' deep.

Explosives: 25# - 11/2" x 8", 60% or 75% primers, 25# - 7/8" x 16", 30% in trim holes, 40# - 11/2" x 16", 45% in 6 hole burn cut, and 275# AN/FO in remainder of round. Powder factor: 4#/cy.

Blasting: Electrical, regular delays, 0 through 15.

Mucking: Scooptram. Guidance: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056":

Spec. Gravity, Material Size(-)0.75": 2.85

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.10%

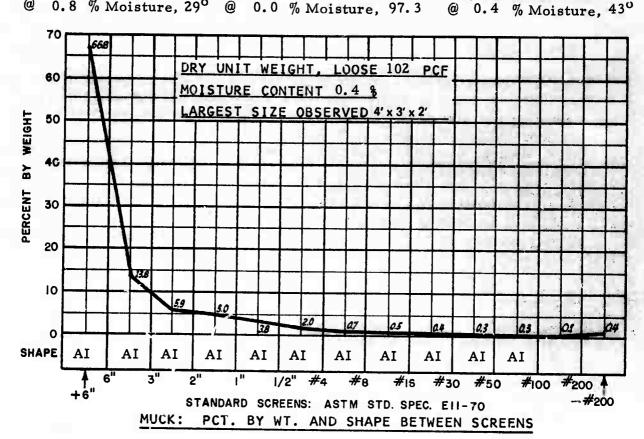
Plastic Limit 17.98% Plasticity Index 0.12 % Toughness Index 0.30 % Shrinkage Limit 17.69% Flow Index 3.90 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 0.8 % Moisture, 33° Angle Slide Steel Plate 0.8 % Moisture, 29°

Apparent Cohesion PSF @ 0.4 % Moisture, 435 Bulk Density PCF

Angle/Repose 10" Drop @ 0.8 % Moisture, 300 Angle Internal Friction @ 0.4 % Moisture, 430



SUMMARY

Rock Class: Igneous: Quartz monzonite, biotitic, fine to medium grained porphyry. High strength. RQD (Est.) 83%. DUW: 162 PCF. Ground Water: Dry. Hardness: NA.

System Class: Conventional Trackless. 18' wide x 16' arch. Three boom jumbo, 47-10 1/2' holes, burn cut PF 4#/CY. Scooptram mucking and haulage to raiserail skip to surface. Support: Roof plates and rock bolts at 4'.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-1 Sheet 2

Lithology: Igneous, biotitic quartz monzonite, fine to medium grained porphyry, with minor steeply inclined joints.

Uniaxial Compressive Strength: 28 KPSI

RQD: (Estimated) 83% Dry Unit Weight: 165 PCF Ground Water: None apparent

Hardness: NA

## TUNNEL DATA:

Size: 18' wide x 16' high, arched back. Grade: (+) 2%.

Ventilation System: 22 KCFM, pressure in heading, 48" pipe and tubing. Underground fans 48", 150 HP, 2 stage. Exhaust in return airway to 3-54", 150 HP, 2 stage surface fans.

Utility System: 6" compressed air, 2" water.

Water Inflow: None apparent.

Power System: 4160/220 for pumps and fans, 110V lighting.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station, rail mounted skip to surface. Personnel and supplies by diesel truck. Support System: 13 1/2" x 9' roof plates, 6' x 3/4" rock bolts @ 4'.

## **EXCAVATION DATA:**

Conventional Trackless system.

Drilling: Gardner-Denver 3 boom jumbo, 3 PR123 drifters, 12' feeds. Drill Round: 47 holes, 1 3/4" diameter, including 6 hole burn cut, and 1 center hole, 4" diameter, all 10 1/2' deep.

Explosives: 25#-1 1/2" x 8", 60% or 75% primers, 25#-7/8" x 16", 30% in trim holes, 40#-1 1/2" x 16", 45% in 6 hole burn cut, and 275# AN/FO in remainder of round. Powder factor: 4#/CY.

Blasting: Electrical, regular delays, 0 through 15.

Mucking: Scooptram. Guidance: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material

Size (-)0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.73

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 20.50% Plastici'y Index 0.36 % Plastic Limit 19.14% Toughness Index 0.058% Shrinkage Limit 17.29 % Flow Index 6.2 %

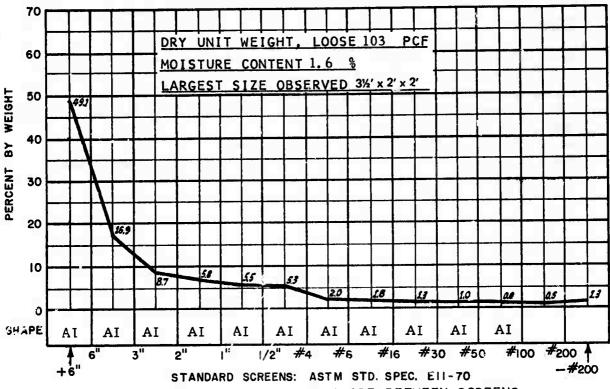
MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop
@ 4.7 % Moisture, 43°
Angle Slide Steel Plate
@ 4.7 % Moisture, 33°

Apparent Cohesion PSF @ 4.9 % Moisture, 210 Bulk Density PCF

0.0 % Moisture, 97.6

Angle/Repose 10" Drop
@ 4.7 % Moisture, 42°
Angle Internal Friction
@ 4.9 % Moisture, 39°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

### SUMMARY

Rock Class: Igneous: Quartz monzonite, biotitic, fine to medium grained porphyry, minor steep angle joints. High strength. RQD (Est.) 83%. DUW: 165 PCF. Ground water: Dry. Hardness: NA

System Class: Conventional Trackless. 18' wide x 16' arch. Three boom jumbo, 47 - 10 1/2' holes, burn cut. PF 4#/CY. Scooptram mucking and haulage, rail 3kip to surface. Support: Roof plates and rock bolts at 4'.

MCN STUDY

9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-2 Sheet 2

Lithology: Igneous, biotitic quartz monzonite, fine to medium grained

porphyry.

Uniaxial Compressive Strength: 32 KPSI

RQD: (Estimated) 92% Dry Unit Weight: 165 PCF Ground Water: None apparent.

Hardness: NA

## TUNNEL DATA:

Size: 12' diameter vertical bore hole, reamed from 1312' to 1212' below collar, from a 13.7/8" diameter pilot hole.

Ventilation System: None in bore hole.

Utility System: 5 to 10 gpm. Water for dust suppression through pilot hole.

Water Inflow: None apparent

Power System: 440V to surface drive motors.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station/

rail mounted skip to surface.

Support System: None in bore hole.

## **EXCAVATION DATA:**

Machine: Robbins H81R Raise Drill. Weight 49 tons. Cutters: 27 Robbins, Steel Disc. Gage: 3-12". Center: 1-11". Interior: 19-12" single and 2-11" twin. Two sets of three 12" dia. TCB roller stabilizers are installed on third points below the cutter head.

Rotation, cutter head: 6 RPM.

Torque: 260 K Foot Lbs. Full Load.

Reaming Full: Total 814K Lbs @ 2400 FSI, net 507 K#.

Muck Disposal: Scooptram, underground.

Power System: 3-440V, 100 HP motors, 1.567: 1 gathering

box ratio.

Guidance System: Survey in pilot hole.

Abrasiveness N. A.

Pot. Wol. Change, Material Size (-)0.056": 0

Spec. Gravity, Material Size(-)0.056": 2.67

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 25. 00 %
Plasticity Index 4. 05 %

Plastic Limit 20.95 % Toughness Index 0.73 % Shrinkage Limit 19.68 % Flow Index 5.50 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop Appare @ 3.4 % Moisture, 33° @ 3.0 Angle Slide Steel Plate Bulk D @ 3.4 % Moisture, 38° @ 0.0

Apparent Cohesion PSF

@ 3.0 % Moisture, 75

Bulk Density PCF

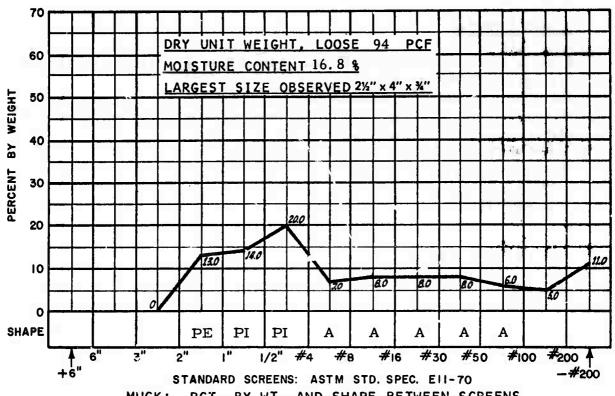
@ 0.0 % Moisture, 100

Angle/Repose 10" Drop

@ 3.4 % Moisture, 32°

Angle Internal Friction

@ 3.0 % Moisture, 37°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

## SUMMARY

Rock Class: Igneous: Quartz monzonite, biotitic, fine to medium grained porphyry. High strength. RQD (Est.) 92%, DUW: 165 PCF. Ground water: Dry. Hardness: NA.

System Class: RBM, Robbins H81R, 12' dia. 27 Robbins disc cutters, 6 RPM, 383.5 Kft. # torque, 507 K# pull average. Mucking and haulage: Scooptram underground, rail skip to surface. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-5 Sheet 2

Lithology: Igneous, biotitic quartz monzonite, fine to medium grained porphyry, frequent flat angled joints.

Uniaxial Compressive Strength: (Estimated) 7 KPSI

RQD: (Estimated) 86%.

Dry Unit Weight: 137 PCF.

Ground Water: None apparent.

Hardness: N.A.

### TUNNEL DATA:

Size: 4' diameter vertical bore hole reamed from 298' to 286' below collar from a 13 7/8" diameter pilot hole.

Ventilation System: Not applicable.

Utility System: 5 to 10 gpm water for dust suppression through pilot hole.

Water Inflow: None apparent.

Power System: 440V to surface drive motors.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station/rail mounted skip to surface. Personnel and supplies by diesel truck.

Support System: None in bore hole.

## **EXCAVATION DATA:**

Machine: Robbins H81R Raise Drill. Weight: 49 tons.

Cutters: 11-Robbins, Steel Disc. Gage: 1-12" twin. Center 1-12" single. Interior: 4-12" twin. Three 12" TCB roller stabilizers are installed at

third points below the cutter head.

Rotation, Cutter head: 6 RPM

Torque: 260 K Foot/lbs. Full Load

Reaming Pull: Net 207K#

Muck Disposal: Scooptram underground.

Power System: 3-440V, 100 HP motors, 1.667: 1 gathering

box ratio.

Guidance System: Survey in pilot hole.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-6 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056": 0

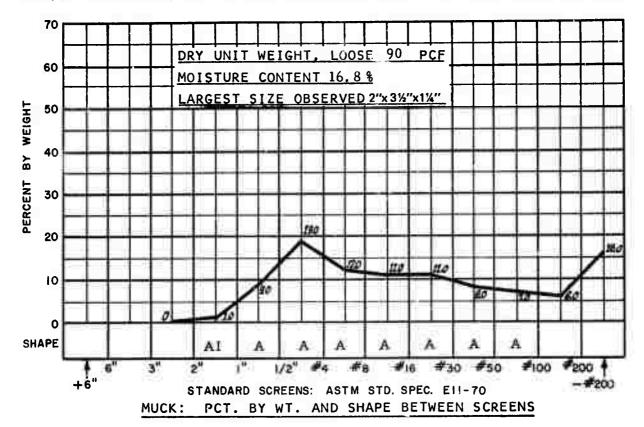
Spec. Gravity, Material Size (-)0, 75": 2.53

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 19.40 % Plasticity Index 1.24 % Plastic Limit 18.16 % Toughness Index 0.31 % Shrinkage Limit 17.27 % Flow Index 4.00 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 3.7 % Moisture, 30° Angle Slide Steel Plate @ 3.7 % Moisture, 32° Apparent Cohesion PSF @ 0.2 % Moisture, 0 Bulk Density PCF @ 0.0 % Moisture, 101 Angle/Repose 10" Drop @ 3.7 % Moisture, 29° Angle Internal Friction @ 0.2 % Moisture, 40°



SUMMARY

Rock Class: Igneous: Quartz monzonite, biotitic, fine to medium grained porphyry, frequent flat angled joints. Low strength (Est.). RQD (Est.) 86%. DUW: 137 PCF. Ground water: Dry. Hardness: NA.

System Class: RBM, Robbins H81R, 4' dia. 11 Robbins disc cutters. 6 RPM, 260 K ft # torque, 207 K # pull (average). Mucking and Haulage: Scooptram underground, rail skip to surface. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-6 Sheet 2

Lithology: Igneous, quartz monzonite porphyry, intensely altered, coarse

Uniaxial Compressive Strength: 7 KPSI.

RQD: (Estimated) 35%. Dry Unit Weight: 158 PCF

Ground Water: None Hardness: N.A.

### TUNNEL DATA:

Size: 15' wide x 14' high, arched back. Grade: (-) 26%.

Ventilation System: 22 KCFM, pressure, 48" pipe and tubing, 150 HP @ 650'.

Utility System: 6" air, 2" water, 4" pump line.

Water Inflow: Minor

Power System: 4160/220, 110V lighting.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station/rail

mounted skip to surface. Personnel and supplies by Diesel truck. Support System: 13 1/2" x 9' roof plates, 6' x 3/4" rock bolts at 4'.

## **EXCAVATION DATA:**

Conventional Trackless System.

Drilling: Three boom hydrojib jumbo, w/PR123 drifters on 12' feeds. Drill Round: 42 holes, 1 3/4" diameter, including 6 hole burn cut, and 1-4" diameter center hole, all 10 1/2' deep.

Explosives: 25#-1  $1/2" \times 8"$ , 60% as primers,  $25\#-7/8" \times 16"$ , 30% in trim holes, 300#-1  $1/2" \times 16"$  in remainder of round. Powder factor: 4.7#/CY.

Blasting: Electrical, regular delays 0 through 15.

Mucking System: Scooptram

Guidance: Laser.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. LK-7 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size(-)0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.68

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

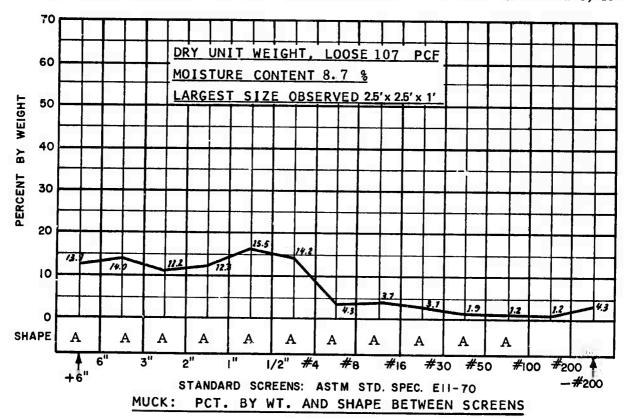
Liquid Limit 18.00% Plasticity Index 0.88 %

Plastic Limit 17.12 % Toughness Index 0.18 % Shrinkage Limit 17.04 % Flow Index 5.00 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 1.7 % Moisture, 29° Angle Slide Steel Plate @ 1.7 % Moisture, 28° Apparent Cohesion PSF @ 0.2 % Moisture, 70 Bulk Density PCF @ 0.0 % Moisture, 114

Angle/Repose 10" Drop @ 1.7 % Moisture, 26° Angle Internal Friction @ 0.2 % Moisture, 45°



#### SUMMARY

Rock Class: Igneous: Quartz monzonite porphyry, intensely altered, course grained. Low strength. RQD (Est.) 85%. DUW: 158 PCF. Ground water: None. Hardness: N.A.

System Class: Conventional Trackless, 15' wide x 14' arch. Three boom jumbo, 42-10 1/2' holes, burn cut. PF 4.7 #/CY. Scooptram mucking and haulage rail skip to surface. Support: Roof plates and rock bolts at 4'.

MDN STUDY 9/1/72

SYSTEM DATA SHEET
MDN

Ident. No. LK-7 Sheet 2

Lithology: Igneous, quartz monzonite, coarse quained with many sulfide veinlets, highly fractured, pronounced orthogonal faulting.

Uniaxial Compressive Strength: 19K.

RQD: (Estimated) 50%. Dry Unit Weight: 165 PCF

Ground Water: Saturated below working levels.

Hardness: N.A.

## TUNNEL DATA:

Size: 12' x 12' Grade: (+) 0.4%

Ventilation System: 14 KCFM, pressure, 24" diameter pipe, 60 HP @ 400'

from airway.

Utility System: 2" water, 4" airline, 8" pump line.

Water Inflow: None upper levels, 20-200 gpm lower levels.

Power System: 2400/480/240/110.

Haulage System: Muck, supplies, personnel by railcars, 8 ton battery locomotives, 10 ton bottom dump devel. cars, 36" gage, 45# rail.

Support System: 10 1/2' x 12" x 12" wood posts, 12" H beam cap sets at 5'

centers in normal ground.

### **EXCAVATION DATA:**

Conventional Rail System.

Drilling: 3 boom hydrojib jumbo, CF79 drifters on 6' shells or D89 drifters on 6' chain feeds.

Drill Round: 52 holes, 1 5/8" diameter, including 2 hole wedge burn and 4 relievers, 5' depth.

Explosives: 100# Carbamite per round (Amogel in wet ground).

Blasting: #6 caps, 8' fuse, timed by order of connection to igniter cord. (Primacord used in place of primer powder) Powder factor 3.8#/CY.

Mucking System: Eimco 40 loader.

Guidance: Transit survey.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident No. SM-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size(-)0.056": 0

Spec. Gravity, Material Size(-)0.75": 2.72

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 12.50% Plasticity Index 1.48% Plastic Limit 11.02% Toughness Index 0.29 % Shrinkage Limit 10.52 % Flow Index 5.1 %

MATERIAL SIZE (-) 2.0 IN.

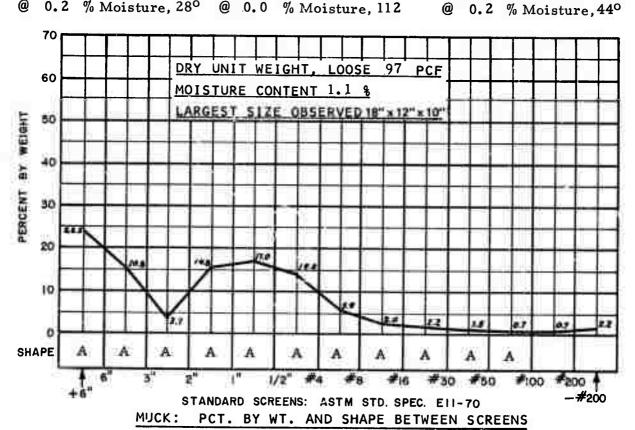
Angle/Repose 1" Drop @ 0.2 % Moisture, 36° Angle Slide Steel Plate @ 0.2 % Moisture, 28°

Apparent Cohesion PSF @ 0.2 % Moisture, 90 Bulk Density PCF Angle/Repose 10" Drop

@ 0.2 % Moisture, 31°

Angle Internal Friction

@ 0.2 % Moisture, 44°



## SUMMARY

Rock Class: Igneous: Quartz monzonite, course grained, many sulfide veinlets. Highly fractured, pronounced orthogonal faulting. High strength. RQD (Est.) 50%. DUW: 165 PCF. Ground water: Dry. Hardness: N.A.

System Class: Conventional Rail. 12' x 12'. Three boom jumbo, 52-5' holes, wedge cut. PF 3.8#/CY. Eimco 40 mucker. Haulage: Rail. Support: Wood posts and steel cap at 5'.

MDN STUDY 9/1/72

SYSTEM DATA SHEET
MDN

Ident. No. SM-1 Sheet 2

Lithology: Metamorphic, granitic gneiss, highly metamorphosed, moderately

to highly fractured, highly silicified. Uniaxial Compressive Strength: 9 KPSI.

RQD: (Estimated) 10%. Dry Unit Weight: 174 PCF.

Ground Water: Minimal-drains to other workings.

Hardness: NA

### TUNNEL DATA:

Size: 13', round, Grade (+) 1/4 percent.

Ventilation System: 10 K CFM. exhaust, 24" pipe

Utility System: 4" air line, 2" water line.

Water Inflow: 5-10 gpm. Power System: 4160/480V.

Haulage System: Personnel, muck, supplies by rail cars.

Support System: None.

### **EXCAVATION DATA:**

Machine: Calweld, Hardrock model, #40.

Weight: 200 tons.

Cutters: 19-Smith Tool Tungsten Carbide Button, Gage: 6-GT-SH 8 roller.

Center: 1-TCB 24" tricone, interior: 12-GT-MH8 roller.

Rotation: Center cutter-26 RPM, Head-12 RPM.

Torque: 347 K # max.

Thrust: 1,128 K #. 677 K# operating

Muck Collection: Buckets from face, 24" conveyor to rear.

Power System: 480V Electro-Hydraulic, 825 HP.

Guidance System: Laser.

Abrasiveness N. A.

Pot. Vol. Change, Material Size : NA

Spec. Gravity, Material Size : NA

ATTERBERG LIMITS, MATERIAL SIZE

IN.

Liquid Limit NA % Plasticity Index NA %

Plastic Limit NA % Toughness Index NA % Shrinkage Limit NA % Flow Index NA %

MATERIAL SIZE

IN.

Angle/Repose 1" Drop
@ % Moisture, NA
Angle Slide Steel Plate
@ % Moisture, NA

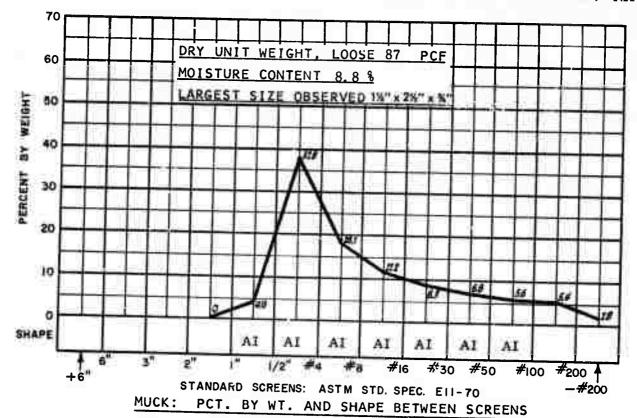
Apparent Cohesion PSF

@ % Moisture, NA

Bulk Density PCF

@ % Moisture, NA

Angle/Repose 10" Drop
@ % Moisture, NA
Angle Internal Friction
@ % Moisture, NA



#### SUMMARY

Rock Class: Metamorphic: Granitic gneiss, highly metamorphosed and silicified, moderately to highly fractured. RQD: (Est.) 10%. DUW: 174 PCF. Medium strength. Ground water: Dry. Hardness: NA

System Class: TBM. Calweld #40, 131 diagram and silicified, an

System Class: TBM, Calweld #40, 13' dia. 19 Smith Tool TCB roller and tricone cutters. RPM: Head 12, center 26. 347K ft # torque, 677 K# thrust.

Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. CL-1 Sheet 2

Lithology: Metamorphic, interlayered transition between quartzite and tactite. Moderately to strongly altered metasediments, with replacement pyrite, chalcopyrite and magnetite, and a high percentage of silicates, very fine to medium grained.

Uniaxial Compressive Strength: 26 KPSI.

RQD: (Estimated) 80% Dry Unit Weight: 178 PCF. Ground Water: None apparent

Hardness: NA

### TUNNEL DATA:

Size: 16' wide x 14 1/2' high, arched back. Grade: (+) 2%.

Ventilation System: 52 KCFM, pressure in heading, 48" pipe and tubing. Underground fans 48", 150 HP, 2 stage. Exhaust in return airway to 3-54", 150 HP, 2 stage surface fans.

Utility System: 6" compressed air, 2" water.

Water Inflow: None apparent.

Power System: 4160/220V for pumps and fans, 110V lighting.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station/rail

mounted skip to surface. Personnel and supplies by diesel truck. Support System: 13 1/2" x 9' roof plates, 6' x 3/4" rock bolts at 4'.

### **EXCAVATION DATA:**

Conventional Trackless System.

Drilling: Gardner-Denver 3 boom jumbo, 3 PR123 drifters, 12' feeds. Drill Round: 42 holes, 1 3/4" diameter, including 6 hole burn cut, and 1 center hole, 4" diameter, all 6' deep.

Explosives:  $15\# - 1\ 1/2" \times 8"$ , 60% or 75% as primers,  $15\# - 7/8" \times 16"$ , 30% in trim holes,  $25\# - 1\ 1/2" \times 16"$ , 45% in 6 hole burn cut, 150# AN/FO in remainder of round. Powder factor 5#/cy.

Blasting: Electrical, regular delays, 0 through 15.

Mucking: Scooptram. Guidance: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-3 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0. 056":

Spec. Gravity, Material Size (-) 0.75": 3.21

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 18.25% Plasticity Index 0.33 % Plastic Limit 17. 92 % Toughness Index 0.06%

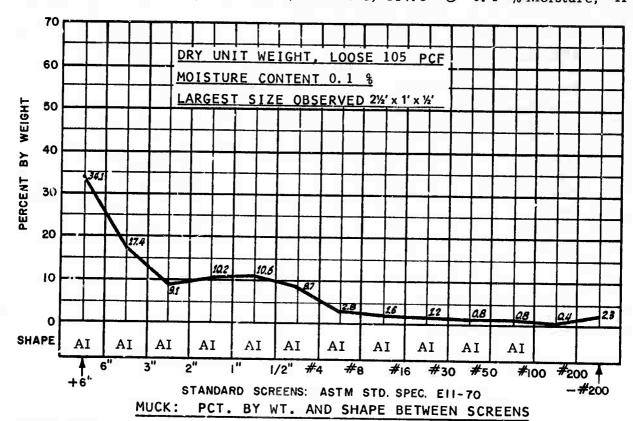
Shrinkage Limit 17.80 % Flow Index 5.50 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 1.5 % Moisture, 30° Angle Slide Steel Plate @ 1.5 % Moisture, 29° @ 0.6 % Moisture, 117.8

Apparent Cohesion PSF @ 0.4 % Moisture, 175 Bulk Density PCF

Angle/Repose 10" Drop @ 1.5 % Moisture, Angle Internal Friction @ 0.4 % Moisture, 41°



#### SUMMARY

Rock Class: Metamorphic: Quartzite-tactite transition, very fine to medium grained, with replacement sulphides and magnetite, high in silicates. High strength. RQD: (Est.) 80%. DUW: 178 PCF. Ground water: Dry. Hardness: NA. System Class: Conventional Trackless. 16' wide x 14-1/2' arch. Three boom jumbo, 42-6' holes, burn cut. PF 5#/CY. Scooptram mucking and haulage, rail skip to surface. Support: Roof plates and rock bolts at 4'.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-3 Sheet 2

Lithology: Metamorphic, tactite, strongly altered calcareous metasediments, with replacement pyrite, chalcopyrite and magnetite, and a high percentage of silicates, fine to very fine grained.

Uniaxial Compressive Strength: 14 KPSI

RQD: (Estimated) 70%

Dry Unit Weight: 181 PCF

Ground Water: None apparent.

Hardness: NA

### TUNNEL DATA:

Size: 15' wide x 14' high, arched back. Grade: (+) 2%.

Ventilation System: 50 KCFM, pressure in heading, 48" pipe and tubing. Underground fans 48", 150 HP, 2 stage. Exhaust in return airway to 3-54", 150 HP, 2 stage surface fans.

Utility System: 6" compressed air, 2" water.

Water Inflow: None apparent.

Power System: 4160/220V for pumps and fans, 110V lighting.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station/rail mounted skip to surface. Personnel and supplies by diesel truck.

Support System: 6" WF Steel Sets at 5'.

### **EXCAVATION DATA:**

Conventional Trackless System.

Drilling: Gardner-Denver 3 boom jumbo, 3 PR123 drifters, 12' feeds.

Drill Round: 42 holes, 1 3/4" diameter, including 6 hole burn cut and 1 center hole, 4" diameter; all 6' deep.

Explosives: 15#-1 1/2" x 8", 60% or 75% as primers, 15#- 8" x 16" 30% in trim holes, 25#-1 1/2" x 16", 45% in 6 hole burn cut, 150# AN/FO in remainder of round. Powder factor 5.5#/CY.

Blasting: Electrical, regular delays, 0 through 15

Mucking: Scooptram. Guidance: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-4
Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75": 3.36

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 19.00% Plasticity Index 1.05 % Plastic Limit 17.95 % Toughness Index 0.19 % Shrinkage Limit 16.43 % Flow Index 5.40 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 2.0 % Moisture, 370 Angle Slide Steel Plate @ 2.0 % Moisture, 300

Apparent Cohesion PSF

@ 0.2 % Moisture, 165

Bulk Density PCF

@ 0.0 % Moisture, 115

Angle/Repose 10" Drop

@ 2.0 % Moisture, 350

Angle Internal Friction

@ 0.2 % Moisture, 430

70 DRY UNIT WEIGHT LOOSE 124 PCF 60 MOISTURE CONTENT 2.1% LARGEST SIZE OBSERVED 27"x 18"x 12" BY WEIGHT 50 40 PERCENT 30 76. 20 13.9 10 2.9 0.8 SHAPE AI ΑI ΑI ΑI ΑI ΑI ΑI ΑI ΑI ΑI ΑI 1/2" #4 #8 #16 #30 #i00 #200 ¶ -#200 STANDARD SCREENS: ASTM STD. SPEC. E11-70 MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Metamorphic: Tactite, fine to very fine grained, with replacement sulphides and magnetite, high in silicates. Medium strength (Est.).

RQD (Est.) 70%. DUW: 181 PCF. Ground water: Dry. Hardness: N.A.

System Class: Conventional Trackless. 15' wide x 14' arch. Three boom jumbo, 42-6' holes, burn cut. PF 5.5#/CY. Scooptram mucking and haulage, rail skip to surface. Support. Steel sets at 5'.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LK-4 Sheet 2

Lithology: Metamorphic, interlayered bands of hematite and martite, highly jointed, normally flat lying, but often highly folded. Natural iron over 60%, silica 5%.

Uniaxial Compressive Strength: 7 KPSI.

RQL: (Estimated) 10% Dry Unit Weight: 207 PCF

Ground Water: Formation generally dry.

Hardness: NA

### TUNNEL DATA:

9'-11 1/2" diameter; normal grade: 0%.

Ventilation System: 3 KCFM, pressure, 8" dia. tube, 5 HP @ 250' from main level.

Utilities: 2" air line, 1" water line, 2-1 1/2" pressure and 1-3" return hydraulic lines.

Water Inflow: None

Power System: 110V lighting, 440V to scraper hoist.

Muck Haulage: 30 HP hoist, and 42" scraper to raise, all rail on main level.

Personnel, rail and ladders; supplies by rail cars and hoist.

Support: Continuous; 9'-6" dia. x 4" WF sets at 45".

#### **EXCAVATION DATA:**

Machine: Calweld Oscillator. Wt: 69 K#.

Cutters: 278 Carboloy drag bits. Gage: 20 rippers (experimental).

Interior: 258 "J" tools.

Rotation: 8 RPM Torque: 1200 K ft.#.

Thrust: 300 K# max., 285 K# operating.

Anchorage: Thrust on installed sets, 285K# operating.

Muck Collection: Flight conveyor to rear of machine, removal by scraper. Power System: Remote power unit; 2-90 gpm, 2500 psi hydraulic pumps and 125 HP motors on main level; thrust and rotation through hydraulic cylinders.

Guidance System: Survey.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MB-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056": 0

Spec. Gravity, Material Size (-) 0.75": 4.34

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 17.8 %
Plasticity Index 2.7 %

Plastic Limit 15.1 % Toughness Index 0.66%

Shrinkage Limit 13.9 % Flow Index 4.1 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 6.2 % Moisture, 37° Angle Slide Steel Plate @ 6.2 % Moisture, 31°

Apparent Cohesion PSF

@ 6.9 % Moisture, 235

Bulk Dessity PCF

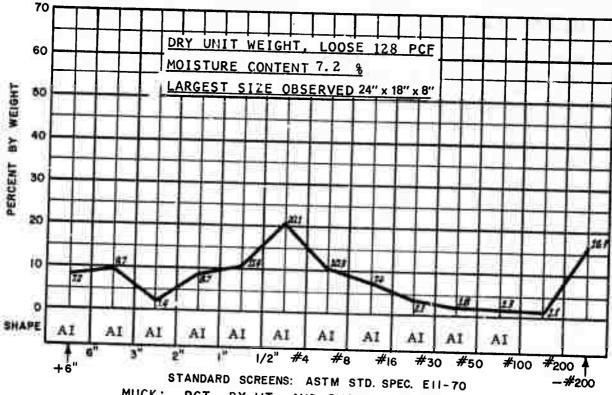
@ 0.0 % Moisture, 141

Angle/Repose 10" Drop

@ 6.2 % Moisture, 35°

Angle Internal Friction

@ 6.9 % Moisture, 35°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Metamorphic: Hematite and martite interlayered, highly jointed, bedding normally flat, often highly folded. Low strength. RQD (Est.) 10%. DUW: 207 PCF. Ground water: Dry. Hardness: NA.

System Class: TBM, oscillator, Calweld #53, 9'11 1/2" dia. 278 Carboloy drag bits. 8 RPM, 1200 K ft # torque, 285 K # thrust. Mucking: Flight conveyor and scraper to raise. Haulage: Rail. Support: Continuous, 9'6" dia. x 4" H sets at 45".

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MB-1 Sheet 2

Lithology: Metamorphic, interlayered hematite and martite, highly jointed, normally flat lying, often highly folded. Natural iron over 60%, silica 5%.

Uniaxial Compressive Strength: NA PSI

RQD: (Estimated) 10%. Dry Unit Weight: NA Ground Water: None

Hardness: NA

#### TUNNEL DATA:

Size: 10' wide x 9'-6" (7' cap and 8' post). Grade: Level

Ventilation System: 4 KCFM pressure, 8" diameter pipe and tubing, 15 HP@

600', and 8" exhaust, 5 HP @ 100'. Utility System: 2" airline, 1" water line

Water Inflow: None

Power System: 2300/440V.

Haulage System Muck, 30 HP hoist and 48" scraper from surge pile at rear of miner to chute - 160 CF cars, 30 ton tandem locomotives on 30" gage 60# rail to shaft pocket, 14 ton skips to surface.

Support System: 8"-58# WF sets, 7' cap, 8' post, at 4'-5", wood lagging and pipe spiling, 8-1" diameter or 6-2" diameter in back.

#### **EXCAVATION DATA:**

Machine: Alpine, Model F-6A Total Weight: 11 tons.

Cutters: 68 Kennametal 43 KH carbide tipped "plumb bob" type, mounted on twin ripper heads at 90° to boom.

Rotation: 60 RPM about horizontal axis; boom moved vertically and horizontally by hydraulic cylinders.

Torque: 49.6 HP.

Thrust: Sumping thrust from 2-10 HP crawler motors.

Anchor Pressure: Crawlers only.

Muc! Collection: Central 14" flight conveyor fed by two gathering arms on inclined apron, discharging to surge pile.

Power System: 440 V. Guidance: Transit lines.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident No. MB-3 Sheet 1

MUCK DATA Test Data NA. Abrasiveness Pot. Vol. Change, Material Spec. Gravity, Material N. A. Size Size ATTERBERG LIMITS, MATERIAL SIZE IN. Liquid Limit % Plastic Limit Shrinkage Limit Plasticity Index % Toughness Index % Flow Index MATERIAL SIZE IN. Angle/Repose 1" Drop Apparent Cohesion PSF Angle/Repose 10" Drop % Moisture, @ % Moisture. % Moisture. Angle Slide Steel Plate Bulk Density PCF Angle Internal Friction % Moisture, % Moisture, % Moisture, 70 DRY UNIT WEIGHT PCF 60 MOISTURE CONTENT LARGEST SIZE OBSERVED 24 "x12"x10" BY WEIGHT 50 40 PERCENT 30

> STANDARD SCREENS: ASTM STD. SPEC. E11-70 PCT. BY WT. AND SHAPE BETWEEN SCREENS

#8

#30

#50

#100

-#200

#16

#### SUMMARY

20

10

0 SHAPE

Rock Class: Metamorphic: Hematite and martite interlayered, highly jointed, bedding normally flat, often highly folded. Low strength. RQD (Est.) 10%. DUW: NA. Ground water: Dry. Hardness: NA.

1/2" #4

System Class: TBM, Twin head, Alpine F-6A, 10' wide x 9'6" heading. 68 Kennametal T. C. tipped bits. 60 RPM, 49.6 HP head torque, 20 HP sumping thrust. Mucking: Gathering arms, flight conveyor. Haulage: Scraper to rail cars to skip. Support: Steel sets, pipe spiles.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MB-3Sheet 2 %

Lithology: Metamorphic, argillaceous quartzite, medium to thin bedded, moderately to highly folded. Beds high angled to vertical, moderate fracturing sub-parallel to beds and vertical across beds.

Uniaxial Compressive Strenght: NA KPSI RQD: 75% (Estimated for vertical hole).

Dry Unit Weight: NA PCF

Ground Water: None

Hardness: NA

### TUNNEL DATA:

Size: 9' W x 10.7', 1 1/2' R. top corner arch. Grade: +1/2%

Ventilation System: 7 KCFM pressure, 24" pipe and tubing, 40 HP at 800'.

Utility System: 4" air line, 2" water line.

Water Inflow: None to minor.

Power System: 2300/480/120 (lighting).

Haulage System: Muck, personnel, supplies by rail ars, 24" gage, 40# rail,

6 ton batter; locomotive, 60 CF side dump cars.

Support System: 9' x 13" mats, parallel to centerline, 2 in top and 2 each

rib, 43/4" x 6' rock bolts per mat.

### **EXCAVATION DATA:**

Conventional Rail System.

Drilling: 3 boom jumbo, 2-S83F and 1-D99 machines, 8' screw feeds. Drill Round: 44 holes: 2-4" and 42-1 5/8" diameter, burn cut, 7' depth.

Explosives: 100# Nilite, 25#-60 WR 1" x 16" primers.

Blasting: Electrical, zero and 14 regular delays. Powder Factor: 5.4#/CY.

Mucking System: Atlas-Copco LM56 overhead.

Guidance: Transit lines.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. ST-1 Sheet 1 MUCK DATA Test Data NA.

Abrasiveness

Pot. Vol. Change, Material

Spec. Gravity, Material

N. A.

@

Size

Size

ATTERBERG LIMITS, MATERIAL SIZE

IN.

Liquid Limit

%

Plastic Limit

Shrinkage Limit

%

Plasticity Index

% Toughness Index

Flow Index

MATERIAL SIZE

IN.

Angle/Repose 1" Drop % Moisture, Angle Slide Steel Plate

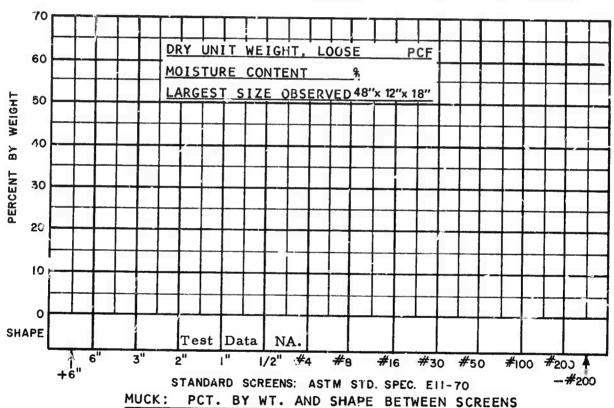
% Moisture.

Apparent Cohesion PSF @ % Moisture.

Bulk Density PCF % Moisture, Angle/Repose 10" Drop % Moisture.

Angle Internal Friction

% Moisture,



SUMMARY

Rock Class: Metamorphic: Argillaceous quartzite, moderately fractured, moderately to highly folded, medium to thin bedded. Strength: NA. RQD (Est.) 75%. DUW: NA. Ground water: None. Hardness: NA.

System Class: Conventional Rail: 9' x 10'7", 3 boom jumbo, 44-7' holes, burn cut. PF 5.4 #/CY. Mucking: Atlas Copco LM56. Haulage: Rail. Support: Rockbolts and mats.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. ST-1 Sheet 2

Lithology: Metamorphic, quartzite, with minor filled veinlets, thin bedded to massive, moderately folded, moderately to highly fractured/jointed, beds dip 750-900.

Uniaxial Compressive Strength: NA

RQD: (Estimated) Vertical: 50%, horizontal 20-30%.

Dry Unit Weight: NA Ground Water: Minor

Hardness: NA

### TUNNEL DATA:

Size: 10' x 10' with 1 1/2' top corner radius. Grade: (+) 0.5%.

Ventilation: 13.5 KCFM, pressure, 24" diameter pipe, 80 MP @ 1700' from

cooling unit.

Utility System: 4" air line, 2" water line, 2" pumpline.

Power System: 2300/480/120.

Haulage System: Muck, Eimco 912B-LHD to skip pocket, skips and rail to surface.

Personnel, Supplies: Rail, cage to level, LHD or Jumbo on level.

Support System: 13" x 9' plates, 5' x 5/8" rock bolts at 3 1/2', plates and rock bolts on ribs where needed.

## **EXCAVATION DATA:**

Conventional Trackless System.

Drilling: 2 boom hydrojib jumbo, 8' feed, D-93 drifters.

Drill Round: 48 holes, 1 5/8" diameter x 8' V cut.

Explosives: 265#, 250# Nilite, 15# Trojan 60 WR. Powder factor, 9.5#/CY.

Blasting: Electrical, Dupont Acudet 0-14 delay caps.

Mucking: Eimco 912B-LHD.

Guidance: Laser

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. CR-1 Sheet 1

MUCK DATA Test Data NA. Abrasiveness Pot. Vol. Change, Material Spec. Gravity, Material N. A. Size Size ATTERBERG LIMITS, MATERIAL SIZE IN. Liquid Limit % Plastic Limit Shrinkage Limit Plasticity Index % Toughness Index % Flow Index MATERIAL SIZE IN. Angle/Repose 1" Drop Apparent Cohesion PSF Angle/Repose 10" Drop % Moisture. % Moisture, % Moisture. Angle Slide Steel Plate Bulk Density PCF Angle Internal Friction % Moisture, % Moisture, % Mcisture, 70 DRY UNIT WEIGHT, LOOSE PCF 60 MOISTURE CONTENT LARGEST SIZE OBSERVED 30"x 14 "x 12" PERCENT BY WEIGHT 50 40 30 20 10 0

STANDARD SCREENS: ASTM STD. SPEC. EII-70
MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

#8

#16

NA.

Test Data

#### SUMMARY

SHAPE

Rock Class: Metamorphic: Quartzite minor filled veinlets, moderately to highly fractured/jointed, moderately folded, beds dip 75° to 90°. Strength: NA. RQD (Est.) 50%. DUW: NA. Hardness: NA.

System Class: Conventional Trackless: 10' x 10', 2 boom jumbo, 48-8' holes, V cut. PF 9.5 #/CY. Mucking: Eimco 912B. Haulage: LHD. Support: Rock bolts and plates.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. CR-1 Sheet 2

-#200

Lithology: Metamorphic, phyllite, with vein quartz and chlorize schist,

highly metamorphosed and folded, with minor faulting.

Uniaxial Compressive Strength: 19 KPSI

RQD: (Estimated) 70% Dry Unit Weight: 187 PCF

Ground Water: Dry Hardness: NA

## TUNNEL DATA:

Size: 7'-6'' wide x 8'-6'' arch.

Ventilation: 7 KCFM, 16" diameter pipe, 30 HP @ 300'. Fan integral with

mechanical cooling unit.

Utility System: 2" water line, 2" airline, 4" water line to cooling unit.

Water Inflow: Minor

Power System: 2400/440/110V.

Haulage System: Muck, supplies, personnel by railcars, 6 and 8 ton locomotives 1 1/2 ton rocker dump cars, 18" gage, 40# rail car passes

80'-300' from face.

Support System: Normally none, 5/8" x 6' rock bolts as required.

### **EXCAVATION DATA:**

Conventional Rail System

Drilling: 2-6' feed air legs, mounting 3" jackhammers.

Drill Round: 34 holes, 5-2" diameter burncut, circular or box relievers

29 x 1 1/4", average advance 10' per round.

Explosives: 140#, 131# AN/FO, 9#-1 x 6", 60% primers.

Blasting: Electrical, 7 millisecond delays, 10 regular delays.

Powder factor, 7.0#/CY.

Mucking: Eimco, model 21.

Guidance: Transit survey.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. HS-1 Sheet 1

Abrasiveness

Pot. Vol. Change, Material

Spec. Gravity, Material

N. A. Size (-)0.056":0 Size (-)0.75": 2.84

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.80% Plasticity Index 2.74 %

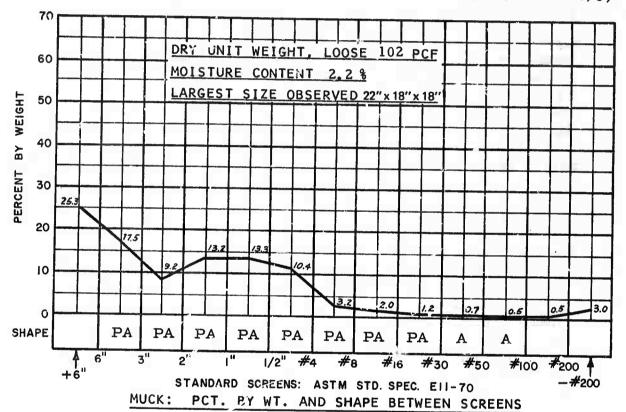
Plastic Limit 16.06 % Toughness Index 1.01 % Shrinkage Limit 15.12 % Flow Index 2.70 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 3.1 % Moisture, 400 Angle Slide Steel Plate @ 3.1 % Moisture, 310

Apparent Cohesion PSF @ 2.0 % Moisture, 160 Bulk Density PCF @ 0.0 % Moisture, 99

Angle/Repose 10" Drop @ 3.1 % Moisture, 340 Angle Internal Friction @ 2.0 % Moisture, 390



#### SUMMARY

Rock Class: Metamorphic: Phyllite with vein quartz and chlorite schist, highly metamorphosed and folded. High strength. RQD (Est.) ?0%. DUW: 187 PCF. Ground water: Dry. Hardness: NA.

System Class: Conventional Rail. 7' 6" wide x 8' 6" arch, two air leg drills, 34-10' holes, burn cut. PF 7.0 #/CY. Mucking: Eimco 21. Haulage: Rail. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. HS-1 Sheet 2

Lithology: Metamoprhie, mica schist, occasional quartz laminations.

Uniaxial Compressive Strength: NA

RQD: (Estimated) 80%. Dry Unit Weight: NA Ground Water: Dry

Hardness: NA

## TUNNEL DATA:

Size: 11'-6" diameter. Grade: (-) 0.03%.

Ventilation: 3.6 KCFM, exhaust, @ 3475', 20" diameter pipe, 40 HP.

Utility System: 4" airline, 4" waterline, 6" pumpline.

Water Inflow: 40 GPM

Power System: 6600V/440V.

Haulage System: Muck, supplies, personnel by railcars, 10 ton locomotive

17 CY cars, 36" gage, 70# rail.

Support System: Half circle bolted steel lagging in fault zones, pinned to ribs.

## **EXCAVATION DATA:**

Machine: Jarva, 12-1100, Total Weight: NA.

Cutters: 30 Reed steel disc and 6 Jarva TCB disc. Cage: 6 TCB QKC-3W.

2 disc. Interior: 28 steel 3 disc QK3. Center: 2 steel 5 disc QK-1.

Rotation: NA RPM.

Torque: NA. Thrust: NA.

Muck Collection: Buckets from face, belt to rear.

Power System: NA. Guidance: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NY-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size

Spec. Gravity, Material Size

ATTERBERG LIMITS, MATERIAL SIZE

IN.

Liquid Limit NA % · Plastic Limit NA

Plasticity Index NA % Toughness Index NA

Shrinkage Limit NA % Flow Index NA

MATERIAL SIZE

IN.

Angle/Repose 1" Drop % Moisture, NA Angle Slide Steel Plate

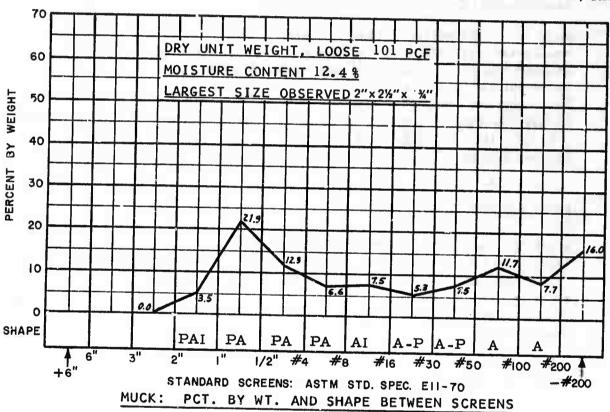
Apparent Cohesion PSF @ % Moisture, NA Bulk Density PCF

Angle/Repose 10" Drop % Moisture, NA Angle Internal Friction

% Moisture, NA

% Moisture, NA

% Moisture, NA



SUMMARY

Rock Class: Metamorphic: Mica schist, occasional quartz lamination. Strength: NA. RQD (Est.) 80%. DUW: NA. Ground water: Dry. Hardness: NA.

System Class: TBM, Jarva 12-1100, 11'6" dia. 30 Reed and 6 Jarva discs. RPM: NA, Torque: NA, Thrust: NA. Mucking: Buckets to belt. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NY-1 Sheet 2

Lithology: Metamorphic, mica schist, occasional quartz laminations.

Uniaxial Compressive Strength: NA.

RQD: (Estimated) 90%. Dry Unit Weight: NA. Ground Water: Dry Hardness: NA.

### TUNNEL DATA:

Size: 8'-6" diameter. Grade: (+) 0.03%.

Ventilation: 18 KCFM, exhaust @ 1500', 12" diameter pipe, 40 HP

Utility System: 4" airline, 4" waterline, 4" pumpline.

Water Inflow: 20 GPM. Power System: 6600/440V.

Haulage System: Muck, supplies, personnel by railcars 10 ton locomotive

13 CY cars, 36" gage, 70# rail.

Support System: Half circle bolted steel lagging in fault zones, pinned to ribs.

## EXCAVATION DATA:

Machine: Jarva 8-806. Total Weight: NA.

Cutters: 14 Reed disc and 3 Jarva TCB disc. Gage 3 TCB disc QKC-3W

Interior, 12 TCB disc QC-3, center 2 steel tooth type.

Rotation: NA RPM.

Torque: NA. Thrust: NA.

Muck Collection: Buckets from face, belt to rear.

Power System: NA. Guidance: Laser.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. NY-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size NA

Spec. Gravity, Material Size NA

ATTERBERG LIMITS, MATERIAL SIZE

IN.

Liquid Limit NA %

Plastic Limit NA % Plasticity Index NA % Toughness Index NA %

Shrinkage Limit NA % Flow Index NA %

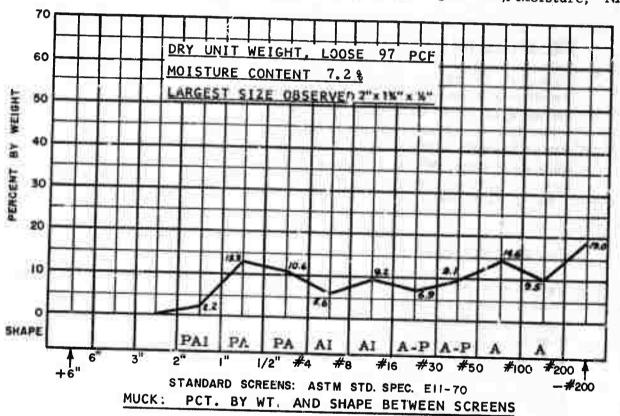
MATERIAL SIZE

IN.

Angle/Repose 1" Drop % Moisture, NA Angle Slide Steel Plate % Moisture, NA

Apparent Cohesion PSF % Moisture, NA Bulk Density PCF @ % Moisture, NA

Angle/Repose 10" Drop % Moisture, Angle Internal Friction % Moisture, NA



SUMMARY

Rock Class: Metamorphic: Mica schist, occasional quartz laminations. Strength: NA. RQD (Est.) 90%. DUW: NA. Ground water: Dry. Hardness: NA.

System Class: TBM, Jarva 8-806, 8'6" dia. 14 Reed and 3 Jarva discs and rollers. RPM: NA. Torque. NA. Thrust: NA. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NY-2 Sheet 2

Lithology: Metamorphic, gray mica schist, occasional quartz seams, mica

varies from dense fine grained to extremely coarse.

Uniaxial Compressive Strength: 11 KPSI.

RQD: (Estimated) 30% Dry Unit Weight: 165 PCF

Ground Water: Major inflow occurs in faults and fault zones.

Hardness: NA

### TUNNEL DATA:

Size: 11', diameter. Grade: (+) 1 to 3%

Ventilation System: 4 KCFM exhaust 14" pipe.

Utility System: 4" waterpipe, no airline. Water Inflow: 60 gpm, drains in ditch

Power System: 4160/480V

Haulage System: Muck, personnel, supplies by rail cars.

Support System: None, occasional semi-circular plates pinned at spring

line in fault zones

### **EXCAVATION DATA:**

Machine: Jarva, Mark 11-1100, Total Weight: 70 tons

Cutters: 34 Reed, type QK steel multiple disc. Gage: 6 triple disc.

Center: 2-triple disc. Interior: 26 triple disc.

Rotation: Cutterhead, 10.75 RPM

Torque: 244 K ft.#

Anchor Pressure: Maximum 3, 402 K#.

Thrust: 1, 134 K#. operating

Muck System: Buckets from face, belt to rear.

Power System: Four 125 HP, 480V motors drive head, 40 HP 480V motor

drive hydraulic system. Guidance System: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET
MDN

Ident. No. QL-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0. 056":

Spec. Gravity, Material Size(-) 0.75": 2.57

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 24.0 %

Plastic Limit 23.3 % Plasticity Index 0.7 % Toughness Index 0.17 %

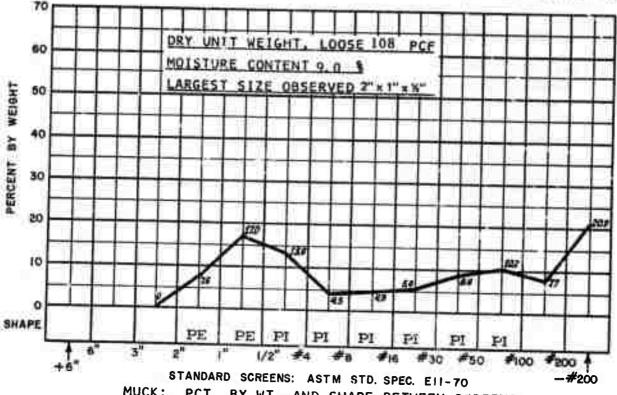
Shrinkage Limit 22.7 % Flow Index 4.0 %

MATERIAL SIZE (-)2.0 IN.

Angle/Repose !" Drop @ 9.8 % Moisture, 390 Angle Slide Steel Plate @ 8.4 % Moisture, 40°

Apparent Cohesion PSF @ 9.3 % Moisture, 125 Bulk Density PCF @ 0.0 % Moisture, 75

Angle/Repose 10" Drop @ 9.8 % Moisture, 370 Angle Internal Friction @ 9.3 % Moisture, 30°



PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Metamorphic: Mica schist, dense, fine grained to extremely coarse occasional quartz seams. Medium strength. RQD (Est.) 30%. DUW: 165 PCF. Ground water: Minor inflows at fault zones. Hardness: NA.

System Class: TBM, Jarva Mark 11-1100, 11' dia. 36 Reed triple discs. Torque: 244 K ft #. Thrust: 1,134 K #. Mucking: Buckets RPM: 10.75. to belt. Haulage: Rail. Support: Minor, semicircular plates in fault zones.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. QL-1 Sheet 2

Lithology: Sedimentary, graywacke ("argillaceous quartzite"), massive to medium bedded, highly folded and fractured, normal dip of bedding 30° to 45°.

Uniaxial Compressive Strength: NA.

RQD: (Estimated) 35%. Dry Unit Weight: NA. Ground Water: None.

Hardness: NA.

## TUNNEL DATA:

Size: 10' wide x 10.8'. Grade: (+) 2%.

Ventilation System: 8 KCFM, exhaust, 16" diameter pipe, 30 HP @ 1800'

and pressure auxiliary, 8" pipe, 5 HP @ 100'.

Utility System: 6" air line, 4" water line.

Water Inflow: None.

Power System: 2300/480/120V.

Haulage System: Muck, personnel, supplies by railcars, 30" gage, 80# and 60# rail, 10 ton trolley locomotives, 200 and 140 Cr bottom dump cars to

skip pocket, 14 ton skips to surface.

Support System: Roof plates and 3/4" x 6' bolts as required.

## **EXCAVATION DATA:**

Conventional Rail System.

Drilling: Hydrojib jumbo, 2 boom, D93 drifters, 1 1/4" round steel on 10' chain feeds.

Drill Round: 36 holes, 1 5/8" diameter, V cut, 8' depth.

Explosives: 210#, 200# Aramonium Nitrate, 10#-7/8" x 8", 70% in ribs and top. Powder factor, 7.5#/CY.

Blasting: Detaprime primers, caps, fuse and igniter cord.

Mucking System: Eimco Model 40 mucker.

Guidance: Transit Lines.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MB-2 Sheet 1

MUCK DATA Abrasiveness N. A. Liquid Limit Plasticity Index

Test Data NA.

Pot. Vol. Change, Material Size :

Spec. Gravity, Material Size

ATTERBERG LIMITS, MATERIAL SIZE

IN.

% %

Plastic Limit Toughness Index

Shrinkage Limit Flow Index

MATERIAL SIZE

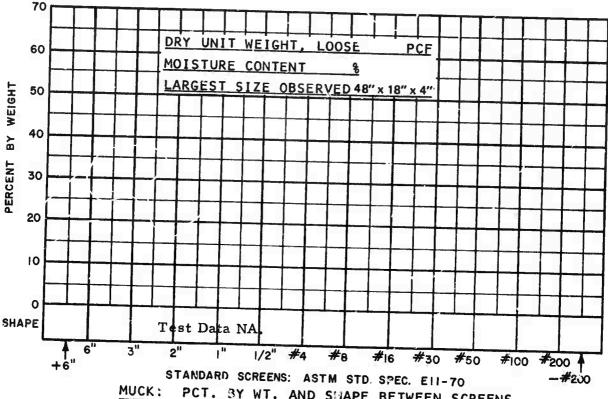
IN.

Angle/Repose 1" Drop % Moisture, Angle Slide Steel Plate % Moisture,

Apparent Cohesion PSF @ % Moisture, Bulk Density PCF @ % Moisture,

Angle/Repose 10" Drop % Moisture. Angle Internal Friction

% Moisture,



PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Graywacke, massive to medium bedded, normal dip 30° to 45°, highly folded and fractured. NA strength. RQD (Est.) 35%. DUW: NA PCF. Ground water: None. Hardness: NA.

System Class: Conventional rail, 10' wide x 10.8'. Two machine jumbo, 36 - 8' holes, V cut. PF 7.5 #/CY. Overhead loader mucking - rail haulage. Support: Rock bolts and plates as required.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MB-2 Sheet 2

Lithology. Sedimentary, sandstone, fine grained, well compacted light brown, over 50 percent quartz.

Uniaxial Compressive Strength: 22 KPSI.

RQD: 92%.

Dry Unit Weight: 166 PCF

Ground Water: Dry. Hardness: Shore 61.

### TUNNEL DATA:

Size: 18'-1" dia. Grade (-) 7%

Ventilation System: 17 K CFM, exhaust, 36" dia. pipe, 75 HP@ 4100". Utility System: 2" water line, 4" pump line. No air line - compressor on machine.

Water Inflow: 5-10 gpm Power System: 4160/480V

Haulage System, Muck: 390' of 30" "piggy back" conveyor supported by a monorail advances with the TBM, discharges on a 36" conveyor suspended from the back of the tunnel. Supply and Personnel: Diesel jeeps and trucks.

Support System: 6" x 8.2# channels x 9.5' or 13.5' @ 4' or 2', secured by 4-5/8" x 4' rock bolts. Channels also support monorail.

## **EXCAVATION DATA:**

Machine: Robbins 181-122 Weight: 260 tons.

Cutters: 47 Robbins, Steel Disc. Gage: 3-12". Center: 1-7 1/2" triple,

Interior: 43-12".

Rotation: 4 1/2 RPM (Center integral with head)

Torque: 1,720 K ft.#

Thrust: 1,580 K# max., 914 K# operating.

Muck Collection: Buckets fixed to head, discharging on a 30" conveyor. Power System: Six-480V., 200 HP motors drive head. Hydraulic pumps power thrust and anchor cylinders.

Guidance System: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. 5-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.065": 0

Spec. Gravity, Material Size (-) 0.75":

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.185 IN.

Liquid Limit 16.90%

Plastic Limit 15.50 % Plasticity Index 1.40 % Toughness Index 0.28 % Shrinkage Limit 15. 18% Flow Index 5.0 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 6.3 % Moisture, 35° Angle Slide Steel Plate

Apparent Cohesion PSF @ % Moisture, NA Bulk Density PCF

Angle/Repose 10" Drop 6.3 % Moisture, 290 Angle Internal Friction @ 4.8 % Moisture, 29°

@ 6.3 % Moisture, 28°

% Moisture, NA

70 DRY UNIT WEIGHT, LOOSE 83 PCF 60 MOISTURE CONTENT 5.4 % LARGEST SIZE OBSERVED 24" x 8" x %" BY WEIGHT 50 40 PERCENT 30 20 10 0 SHAPE PI PI $\mathbf{p}\mathbf{I}$ PI 1/2" #4 #8 #16 #30 #100 #200 STANDARD SCREENS: ASTM STD. SPEC. E11-70 -#200

MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Sandstone, fine grained, well compacted, over 50% quartz. High strength. RQD: 92%. DUW: 171 PCF. Ground water: Dry. Hardness: Shore 61.

System Class: TBM, Robbins 181-122, 18' 1" dia. 47 Robbins disc cutters. RPM: 4-1/2, 1,720 K FT. # torque, 914 K# thrust. Mucking: Buckets to belt conveyor. Haulage: Traveling conveyor - suspended conveyor - skip to surface. Support: Channels and rock bolts at 4' or 2', continuous.

MDN STUDY

9/1/72

SYSTEM DATA SHEET MDN

Ident. No. Sheet 2

Lithology: Sedimentary, sandstone, fine grained, well compacted light brown, over 50 percent quartz.

Uniaxial Compressive Strength: 22 KPSI.

RQD: 92%.

Dry Unit Weight: 166 PCF.

Ground Water: Dry. Hardness: Shore 61.

## TUNNEL DATA:

Size: 18'-1" dia. Grade (+) 2%.

Ventilation System: 17 K CFM, exhaust, 36" dia. pipe, 75 HP @ 4800'.

Utility System: 2" water line, 4" pump line. No air line - compressor on machine.

Water Inflow: 5-10 gpm. Power System: 4160/480V.

Haulage System, Muck: 390' of 30" "piggy back" conveyor supported by a monorail advances with the TBM, discharges on a 36" conveyor suspended from the back of the tunnel. Supply and Personnel: Diesel jeeps and trucks.

Support System: 6" x 8.2# channels x 9.5' or 13.5' @ 4' or 2', secured by 4-5/8" x 4' rock bolts. Channels also support monorail.

# EXCAVATION DATA:

Machine: Robbins 181-122 Weight: 260 tons.

Cutters: 47 Robbins, Steel Disc. Gage: 3-12". Center: 1-7 1/2" triple, Interior: 43-12".

Rotation: 4 1/2 RPM (Center integral with head)

Torque: 1,720 Kft #

Thrust 1,580 K# max., 747 K# operating.

Muck Collection: Buckets fixed to head, discharging on a 30" conveyor.

Power System: Four-480V., 200 HP motors drive head. Hydraulic pumps power thrust and anchor cylinders.

Guidance System: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. 7-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056":

Spec. Gravity, Material Size (-) 0.75": 2.63

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 23.0 %

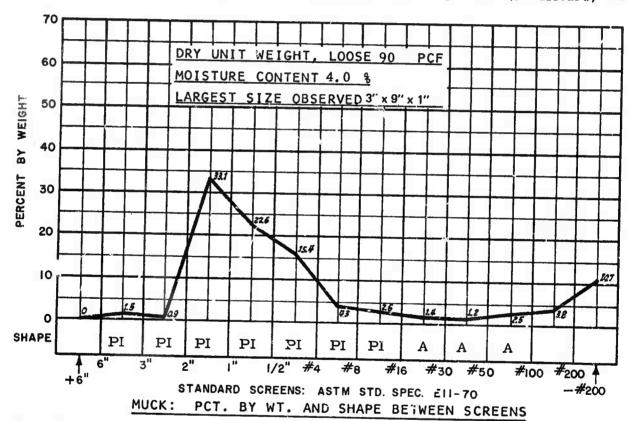
Plastic Limit 17.63% Plasticity Index 5.37 % Toughness Index 0.78 % Shrinkage Limit 17.58 % Flow Index 6.90%

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop 2.6 % Moisture, 32° Angle Slide Steel Plate @ 2.6 % Moisture, 29°

Apparent Cohesion PSF 2.8 % Moisture, 0 Bulk Density PCF 0.0 % Moisture, 92.8

Angle/Repose 10" Drop @ 2.6 % Moisture, 31° Angle Internal Friction @ 2.8 % Moisture, 44°



SUMMARY

Rock Class: Sedimentary: Sandston, fine grained, well compacted, over 50% quartz. High strength. RQD: 92%. DUW: 171 PCF. Ground water: Dry. Hardness: Shore 61.

System Class: TBM, Robbins 181-122, 18'1" dia. 47 Robbins disc cutters.

4-1/2 RPM, 1,720 K FT # torque, 747 K# thrust. Mucking: Buckets to belt conveyor.

Haulage: Traveling conveyor - suspended conveyor - skip to surface. Support: Channels and rock bolts at 4' or 2', continuous.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. 7-2 Sheet 2

Lithology: Sedimentary, "shale", massive to thinly-laminated, interbedded siltstone and shale, with minor sandstone and limestone layers. Grain size varies from fine to coarse, quartz content from 24 to 33%.

Uniaxial Compressive Strength: Four major beds: 22 K to 29 KPSI, three minor beds: 12 K to 17 KPSI. Weighted Average: 23 KPSI.

RQD: (Estimated) 90%. Dry Unit Weight: 152 PCF.

Ground Water: Dry

Hardness: Shore 41 to 55 parallel to bedding planes, 41 to 54 perpendicular.

### TUNNEL DATA:

Size: 24' wide x 7 1/2' rectangular. Grade: Varies

Ventilation System: 80-100K CFM, pressure

Utility System: 4" air, 4" water, 4" pump, where required.

Water Inflow: Normally none.

Power System: 110V. lighting-all equipment diesel or air powered.

Haulage System: Wagner ST-5 Scooptrams, 16 ton shuttle cars to conveyors, 1 1/2 CY loaders for cleanup. Personnel and supplies, diesel jeeps and trucks

Support System: 5/8" x 6' rock bolts on 4' x 4' pattern, 11" wide x 10' roof plates where required.

### **EXCAVATION DATA:**

Conventional Trackless System.

Drilling: Two boom hydrojib jumbos, AR93 drifters, 14' feed.

Drill Round: 35 holes, 1 3/4" diameter, 10 1/2 to 11' deep, and 1-6' buster hole, V-cut.

Explosives:  $16\# -11/4" \times 8"$ , 75% primers,  $32\# -11/4" \times 12"$  RXL, 60% in lifters, 11# coalite 5Y,  $11/4" \times 12"$  in back holes, 175# AN/FO in remainder of round. Powder factor: 3.5#/CY.

Blasting: Electrical, MS delays. Mucking: Wagner ST-5 Scooptrams.

Guidance: Transit/Laser.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. 11-3
Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material

Spec. Gravity, Material

Size (-) 0.056": 0

Size (-) 0.75": 2.65

ATTERBERC LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 15.60% Plasticity Index 0.79 %

Plastic Limit 14.81% Toughness Index 0.26 %

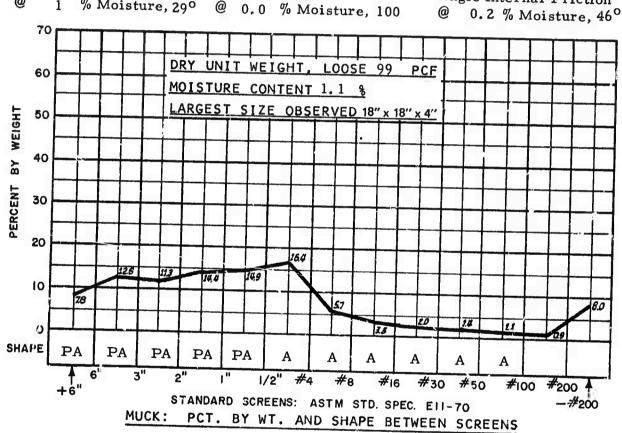
Shrinkage Limit 14.51 % Flow Index 3.00 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop % Moisture, 250 Angle Slide Steel Plate % Moisture, 290 1

Apparent Cohesion PSF @ 0.2 % Moisture, 550 Bulk Density PCF

Angle/Repose 10" Drop 1 % Moisture, 250 Angle Internal Friction



SUMMARY

Rock Class: Sedimentary: Shale and siltstone, minor sandstone and limestone, thin to massive, fine to coarse grained. High strength. RQD (Est.) 90%. DUW: 152 PCF. Ground water: Dry. Hardness: Shore, 41-55.

System Class: Conventional trackless. 24' wide x 7-1/2', rectangular. Two boom jumbo, 35-1-3/4" holes, V-cut. PF 3.5#/CY. Mucking: Scooptram. Haulage: Scooptram and/or shuttle cars to conveyor. Support: Rock bolts, 4' x 4' pattern.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. 11-3 Sheet 2

Lithology: Sedimentary, "shale", massive to thinly laminated, interbedded siltstone and shale, with minor sandstone and limestone layers. Grain size varies from fine to coarse, quartz content from 24 to 33%.

Uniaxial Compressive Strength: Four major beds: 22 K to 29 KPSI, three minor beds: 12 K to 17 KPSI. Weighted Average: 22 KPSI.

RQD: (Estimated) 90%.

Dry Unit Weight: 166 PCF.

Ground Water: Dry.

Hardness: Shore 41.0 to 55 parallel to bedding planes, 41 to 54 perpendicular.

### TUNNE L DATA:

Size: 18' wide x 8 1/2' high, rectangular. Grade: Level.

Ventilation System: 20 KCFM exhaust from face, pressure to entry, 40 HP.

Utility System: 2" water line (250 cfm compressor on machine trailer).

Water Inflow: None.

Power System: Cable to trailer mounted transformer.

Haulage: Muck by diesel shuttle car to conveyor, personnel and supplies by diesel truck.

Support System: 5/8" rock bolts, normally 6' long on 4' x 4' spacing, as required.

## EXCAVATION DATA:

Machine: Atlas-Copco 4 head prototype. Weight: 180 LT. Two 4' dia. heads are mounted on each side of center on horizontal booms rotated about vertical pivots. Heads are rotated around boom centerlines by motors and reducers integral with the booms; booms and heads rotate from side to forward positions.

Cutters: 48 Sandvik T. C., drag type, mounted on head peripheries. Leading cutters, 40mm wide, 8 per head; Finish cutters, 120mm wide, 4 per head.

Rotation: Upper heads: 3 1/4 RPM. Lower: 1 5/8 RPM.

Torque: Head rotation: 80 KW. Boom rotation: 100 LT per boom.

Thrust: 488 LT produced by 4 hydraulic cylinders between advanced and front units.

Anchorage: Two top and two side cylinders, approximately 1,000 K#.

Muck Collection: Flight conveyors move muck from sides to a central 26" flight conveyor, discharging on a 9 1/2" dia. star wheel. The wheel feeds a 25" belt conveyor, transfering muck to a Joy loader and shuttle cars.

Power System: 4160/600/120V, 60 Hz. Head rotation: 4-80 KW motors, hydraulics: 2-78 KW motors, 2300 psi.

Guidance: Transit/Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. 11-4 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material

Size (-) 0.056'': 0

Spec. Gravity, Material Size (-) 0.75": 2.78

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 15.80% Plasticity Index 0.20%

Plastic Limit 15.60% Toughness Index 0.05% Shrinkage Limit 13.26 % Flow Index 4.00 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop

@ 0.9% Moisture, 28°

Angle Slide Steel Plate

@ 0.9% Moisture, 28°

Apparent Cohesion PSF

@ 0.2% Moisture, 282

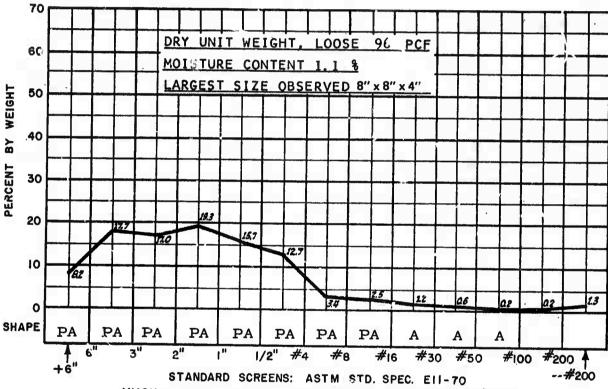
Bulk Density PCF

0.0% Moisture, 100

Angle/Repose 10" Drop

@ 0.9 % Moisture, 29°
Angle Internal Friction

@ 0.2 % Moisture, 54°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Sedimentary: Shale and siltstone, minor sandstone and limestone, thin to massive, fine to coarse grained. High strength. RQD (Est.) 90%. DUW: 166 PCF. Ground water: Dry. Hardness: Shore 41-55.

System Class: TBM, Atlas-Copco. 18' wide x 8-1/2' rect. heading. Sandvik TC "drag" bits. 12/head, 4 heads. RPM 3 1/4 normal. Torque 80 KW/head, 100 LT/boom. 480 LT thrust. Mucking: Flight conveyor - starwheel-belt-loader. Haulage: Shuttle car to conveyor. Support: Rock bolts at 4'.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. 11-4 Sheet 2

Lithology: Sedimentary, "shale", massive to thinly laminated, interbedded siltstone and shale, with minor sandstone and limestone layers. Locally highly faulted and fractured. Grain size varies from fine to coarse.

Uniaxial Compressive Strength: 22K PSI (weighted average).

RQD: (Estimated) 65%. Dry Unit Weight: 168 PCF.

Ground Water: None.

Hardness: Shore 41 to 55 parallel to bedding planes, 41 to 54 perpendicular.

### TUNNEL DATA:

Size: 18'-1" diameter. Grade: (+) 10%.

Ventilation System: 18K CFM, exhaust, 36" diameter pipe, 120 HP @ 7200'. Utility System: 2" water, 4" pump line from sump at 4200' approximate.

Water Inflow: 5-10 gpm. Power System: 4160/480V.

Haulage System Muck, 30" - "piggy back" conveyor supported by monorail advances with TBM, feeds a 36" conveyor suspended from back of tunnel.

Supply and Personnel: Diesel jeeps and trucks.

Support System: 6" x 8.2# channels x 13.5' at 2', secured by 6-5/8" x 6' ock bolts, lagging under channels.

## **EXCAVATION DATA:**

Machine: Robbins 181-122. Total weight: 260 tons.

Cutters: 47 Robbins, steel disc, w/Esco rings, Gage: 3-12".

Center: 1-7 1/2" triple. Interior 43-12".

Rotation: 4 1/2 RPM Torque: 1,147 K#. Thrust: 769K#.

Muck System: Buckets fixed to head, discharge on conveyors. Power System: Four - 480V, 200 HP motors drive head.

Guidance: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. 72-1 Sheet 1

Aprasiveness N. A.

Pot. Vol. Change, Material

Size (-)0.056": 0

Spec. Gravity, Material Size (-)0.75": 2.72

# ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.00% Plasticity Index 0.90 %

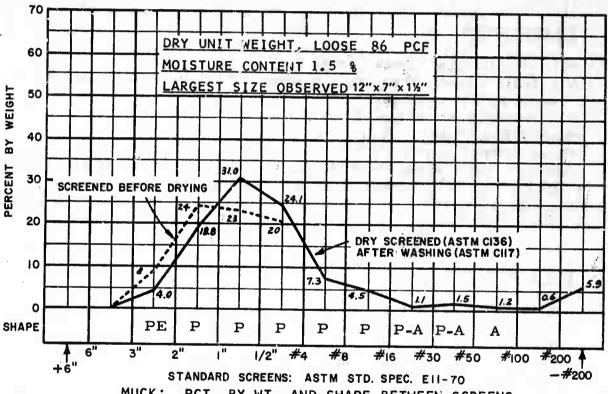
Plastic Limit 17.10 % Toughness Index 0.20 % Shrinkage Limit 15.58 % Flow Index 4.40 %

# MATERIAL SIZE (-)2.0 IN.

Angle/Repose 1" Drop % Moisture, 36° @ 1.3 Angle Slide Steel Plate  $^{(0)}$  1.3 % Moisture, 300

Apparent Cohesion PSF @ 1.0 % Moisture, 170 Bulk Density PCF @ 0.0 % Moisture, 100

Angle/Repose 10" Drop @ 1.3 % Moisture, 320 Angle Internal Friction @ 1.0 % Moisture, 41°



PCT. BY WT. AND SHAPE BETWEEN SCREENS

### SUMMARY

Sedimentary: "Shale" siltstone and shale interbedded, minor Rock Class: sandstone and limestone layers. Massive to thinly laminated, fine to coarse grained. High strength. RQD (Est.) 65%. DUW: 168 PCF. Ground water: None. Hardness: 41 - 55 shore.

System Class: TBM, Robbins 181-122, 18'1" dia. 47 Robbins disc cutters. 4-1/2 RPM, 1,476 K FT # Torque, 769 K# Thrust. Mucking: Buckets to belt. Haulage: Conveyor.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. 72-1 Sheet 2

Lithology: Sedimentary, conglomerate ("breccia") 1/4"-10" rounded to angular boulders, cobbles, pebbles in a predominantly limestone matrix, w/chert, schist diabase fragments, well to moderately consolidated.

Uniaxial Compressive Strength: NA.

RQD: (Estimated) 65%. Dry Unit Weight: 171 PCF Ground Water: Normally dry.

Hardness: NA.

### TUNNEL DATA:

Size: 9' x 10' high. Grade: Level.

Ventilation System: 10 KCFM, pressure, 24" diameter pipe, 50 HP @ 1000', from coil heat exchanger.

Utility System: 6" air line, 2" water line.

Water Inflow: None.

Power System: 4160/480/120V.

Haulage System: Muck, supplies,  $p^{\epsilon}$ . Innel by railcars, 4 and 6 ton battery

locomotives 44 CF rocker dump (acs, 18" gage, 30# rail.

Support System: 5/8" x 6' rock bolts, 3', 4 1/2' or 6' roof plates, 21 bolts

and 7 plates per 5' span.

### **EXCAVATION DATA:**

Conventional Rail System.

Drilling: 3 boom hydraulic jumbo, 7' chain feeds, and 3" bore drifters, 7/8" hex steel.

Drill Round: 42 to 50-1 3/8" diameter holes including 4 hole V cut and 4 hole baby V or 5 hole burn cut, average advance 5 1/2".

Explosives: 150#, 25# Amogel, #4-40% primers and cushion, 125# Carbamite PB. Powder Factor, 8.2#/CY.

Blasting: #6 caps, 8' fuse, detonated electrically, timed by order of connection to igniter cord.

Mucking System: Eimco Model 21 Loader.

Guidance: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MSU-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size(-) 0.056" : 0

Spec. Gravity, Material Size (-) 0.75" : 2.74

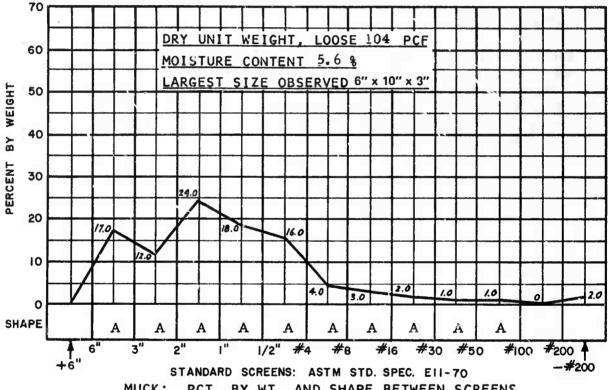
# ATTERBERG LIMITS, MATERIAL SIZE (-) 0,056 IN.

Liquid Limit 13.80 % Plasticity Index 1.03 %

Plastic Limit 12.77 % Toughness Index 0.32 % Shrinkage Limit 10.78% Flow Index 3, 20 %

### MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 0.4 % Moisture, 350 Angle Slide Steel Plate 0.4 % Moisture, 270 Apparent Cohesion PSF @ 0.3 % Moisture, 410 Bulk Density PCF 0.0 % Moisture, 111 Angle/Repose 10" Drop 0,4 % Moisture, 29° Angle Internal Friction @ 0.3 % Moisture, 46°



PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Sedimentary: Conglomerate, "breccia," 1/4" to 10", limestone, chert, schist, diabase fragments, well to moderately consolidated. Strength, NA. RQD (Est.) 65%. DUW: 171 PCF. Ground water: Dry. Hardness, NA.

System Class: Conventional Rail, 9' wide x 10', three boom jumbo, 42 to 50-1-3/8" holes, burn cut. PF 8.2 #/CY. Mucking: Eimco 21. Haulage: Rail. Support: Rock bolts and plates, continuous.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MSU-1 Sheet 2

Lithology: Sedimentary, conglomerate, ("breccia") 1/4"-4" boulders, cobbles, and pebbles, rounded to angular in a predominantly limestone matrix, w/chert, schist and diabase fragments, well consolidated.

Uniaxial Compressive Strength: NA.

RQD: (Estimated) 80%. Dry Unit Weight: 171 PCF

Ground Water: None

Hardness: NA.

# TUNNEL DATA:

Size: 9' wide x 10' high, arched. Grade: Level.

Ventilation System: 9 KCFM, pressure, 24" diameter pipe, 50 HP @ 1300' from coil heat exchanger.

Utility System: 6" air line, 2" water line.

Water Inflow: None.

Power System: 4160/480/120V.

Haulage System: Muck, supplies, personnel by railcars, 4 and 6 ton battery

locomotives, 44 cu. ft. rocker dump cars, 18" gage, 30# rail.

Support System: 5/8" x 6' rock bolts, 3', 4 1/2' or 6' roof plates, 21 bolts

and 7 plates per 5' span.

## **EXCAVATION DATA:**

Conventional Rail System.

Drilling: 2 boom jumbo, 6' chain feeds and 3" bore drifters.

Drill Round: 50-1 3/8" diameter holes, including 4 hole V cut and 4 hole baby V, 5 1/2' average advance.

Explosives: 122# average, 40% Amogel #4 or 40% primers and carbamite. Powder Factor, 6.7#/CY.

Blasting: #6 caps, 8' fuse, detonated electrically, timed by order of connection to igniter cord.

Mucking System: Eimco Model 21 loader.

Guidance: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MSU-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size

Spec. Gravity, Material Size NA

ATTERBERG LIMITS, MATERIAL SIZE

IN.

Liquid Limit NA %

Plastic Limit NA % Plasticity Index NA % Toughness Index NA % Shrinkage Limit NA Flow Index NA %

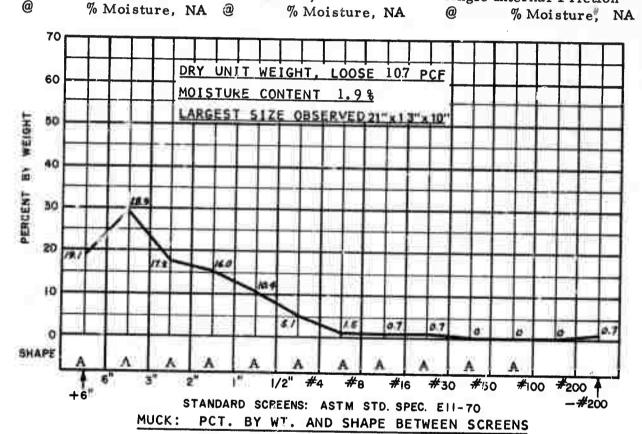
MATERIAL SIZE

IN.

Angle/Repose 1" Drop % Moisture, NA Angle Slide Steel Plate

Apparent Cohesion PSF % Moisture, NA @ Bulk Density PCF

Angle/Repose 10" Drop % Moisture, NA Angle Internal Friction



#### SUMMARY

Rock Class: Sedimentary: Conglomerate, "breccia," 1/4" - 4" limestone, chert schist, diabase fragments, well consolidated. Strength: NA. RQD (Est.) 80%. DUW: 171 PCF. Ground water: None. Hardness: NA.

System Class: Conventional Rail. 9' wide x 10'. Two machine jumbo, 50 holes, V cut. PF 6.7 #/CY. Mucking: Eimco 21. Haulage: Rail. Support: Roof plates and rock bolts, continuous.

MUN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MSU-2 Sheet 2

Lithology: Sedimentary, limestone, light to medium gray, fine grained, some chert nodules, traces to occasional clay partings.

Uniaxial Compressive Strength: 19 KPSI

RQD: (Estimated) 100 percent. Dry Unit Weight: 160 PCF.

Ground Water: Table above tunnel, occasional seepage from minor fractures and faults.

Hardness: Shore, 46.

# TUNNEL DATA:

Size: 13'-8" diameter. Grade (+) 1/4 percent. Ventilation System: 21 K CFM exhaust, 28" pipe.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 40 to 120 gpm. Power System: 4160/480V.

Haulage System: Muck, supplies, personnel, by rail cars.

Support System: None.

# **EXCAVATION DATA:**

Machine: Alkirk Hardrock. Weight 400 tons. Cutters: 28-Lawrence Mfg. Company, Tungsten Carbide Button, roller, disc, and tricone. Gage: 5-15" TCB roller. Center: 1-24" TCB tricone. Interior: 11-15" TCB disc., 11-15" TCB roller.

Rotation: Center cutter-30 RPM, Head-9 RPM.

Torque: Head 206 K ft. # Thrust: 614 K# operating

Muck Collection: Buckets from face discharging on 24" belt conveyor.

Power System: Electro-Hydraulic. Total HP: 910.

Guidance System: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LAW-2 Sheet

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.065":

Spec. Gravity, Material Size (-) 0.75". 2.83

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.185 IN.

Liquid Limit 12.5 %

Plastic Limit 12.3 % Plasticity Index 0.2 7 Toughness Index 0.05 %

Shrinkage Limit 9.6 % Flow Index 4.0 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 5.4 % Moisture, 390 Angle Slide Steel Plate

Apparent Cohesion PSF @ % Moisture, NA Bulk Density PCF

Angle/Repose 10" Drop @ 5.4 % Moisture, 38° Angle Internal Friction 7

% Moisture, 30°

@ 5.4 % Moisture, 31° @

% Moisture, NA

70 DRY UNIT WEIGHT. LOOSE 92 PCF 60 MOISTURE CONTENT 7.2 % LARGEST SI75 OBSERVED 3" x 2" x 1/2" BY WEIGHT 50 40 PERCENT 30 20 18.0 10 79 3.0 35 0 SHAPE PIPAI  $_{\rm PI}$ PI Ι ΑI Ι 1/2" #4 #8 #16 #30 #100 #200 STANDARD SCREENS: ASTM STD. SPEC. E11-70 -#200

MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, some chert nodules, occasional clay partings. High strength. RQD (Est.) 100%. DUW: 160 PCF. Ground water: Minor. Hardness: Shore 46.

System Class: TBM, Alkirk Hardrock, 13' 8" dia. 28 Lawrence TCB roller, disc, tricone cutters. RPM: Center 30, head 9. Torque: 206 K ft #. Thrust: 614 K #. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LAW-2 Sheet 2

Lithology: Sedimentary, limestone, light to medium gray, fine grained, some chert nodules, traces to occasional clay partings.

Uniaxial Compressive Strength: 19 KPSI.

RΩD: (Estimated) 100 percent. Dry Unit Weight: 160 PCF.

Ground Water: Table above tunnel, occasional seepage from minor fractures and faults.

Hardness: Shore, 46.

# TUNNEL DATA:

Size: 13'-8" diameter. Grade (+) 1/4 percent. Ventilation System: 20 K CFM exhaust, 28" pipe. Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 40 to 120 gpm. Power System: 4160/480V.

Haulage System: Muck, supplies, personnel, by rail cars.

Support System: None.

# **EXCAVATION DATA:**

Machine: Alkirk Hardrock. Weight 400 tons. Cutters: 28-Lawrence Mfg. Company, Tungsten Carbide Button, roller, disc, and tricone. Gage: 5-15" TCB roller. Center: 1-24" TCB tricone. Interior: 11-15" TCB disc., 11-15" TCB roller.

Rotation: Center cutter-30 RPM, Head-9 RPM.

Torque: 206 K ft. #.

Thrust: 614 K# operating.

Muck Collection: Buckets from face, discharging on 24" belt conveyor.

Power System: Electro-Hydraulic. Total HP: 919.

Guidance System: Laser.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. LAW-3 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0,065": 0

Spec. Gravity, Material Size(-) 0.75": 2.80

ATTERBERG LIMITS, MATERIAL SIZE (-)0.185 IN.

Liquid Limit 11.8 % Plasticity Index 1.2 %

Plastic Limit 10.6 % Toughness Index 0.41%

Shrinkage Limit 10.0 % Flow Index 2.9 %

MATERIAL SIZE (-) 2.0 IN.

% Moisture, NA

Angle/Repose 1" Drop 6.1% Moisture, 41° Angle Slide Steel Plate 8.4% Moisture, 380

Apparent Cohesion PSF % Moisture, NA Bulk Density PCF

Angle/Repose 10" Drop @ 6.1 % Moisture, 40° Angle Internal Friction % Moisture, 320

70 DRY UNIT WEIGHT. LOOSE PCF 60 MOISTURE CONTENT 5.5 % LARGEST SIZE OBSERVED 3" x 21/" x 1/2" BY WEIGHT 50 40 PERCENT 30 259 20 202 196 10 0 SHAPE PAI PAI PIPAI Ι Ι Ι I Ι 1/2" #4 #16 #8 #100 STANDARD SCREENS: ASTM STD. SPEC. E11-70 -#200 MUCK:

PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, some chert nodules occasional clay partings. High strength. RQD (Est.) 100%. DUW: 160 PCF. Ground water: Minor. Hardness: Shore 46.

System Class: TBM, Alkirk Hardrock, 13' 8" dia. 28 Lawrence TCB roller, disc, tricone cutters. RPM: Center 30, head 9. Torque: 206 K ft #. Thrust: 614 K #. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LAW-3 Sh et 2

Lithology: Sedimentary, limestone, light to medium gray, fine grained, some chert nodules, traces to occasional clay partings.

Uniaxial Compressive Strength: 19 KPSI.

RQD: (Estimated) 100 percent. Dry Unit Weight: 160 PCF.

Ground Water: Table above tunnel, occasional seepage from minor

fractures and faults. Hardness: Shore, 46.

# TUNNEL DATA:

Size: 13'-8" diameter. Grade (+) 1/4 percent. Ventilation System: 21 K CFM exhaust, 28" pipe.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 40 to 120 gpm. Power System: 4160/480V.

Haulage System: Muck, supplies, personnel, by rail cars.

Support System: None.

# EXCAVATION DATA:

Machine: Alkirk Hardrock. Weight 400 tons. Cutters: 28-Lawrence Mfg. Company, Tungsten Carbide Button, roller, disc, and tricone.

Gage: 5-15" TCB roller. Center: 1-24" TCB tricone. Interior: 11-15" TCB disc., 11-15" TCB roller.

Rotation: Center cutter-30 RPM, Head-9 RPM.

Torque: Head 206 K ft. #.

Thrust: 540 K ft. #.

Muck Collection: Buckets from face discharging on 24" belt conveyor.

Power System: Electro-Hydraulic. Total HP: 910.

Guidance System: Laser.

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056";

Spec. Gravity, Material Size (-)0.75": 2.73

ATTERBERG LIMITS, MATERIAL SIZE (-) 0,056 IN.

Liquid Limit 20.2 %

Plastic Limit 20.0 % Plasticity Index 0.2 % Toughness Index 0.95 %

Shrinkage Limit 13.5 % Flow Index 4.7 %

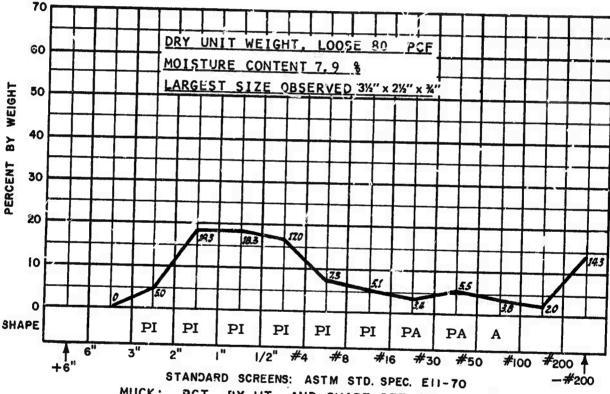
MATERIAL SIZE (-) 2.0 IN.

% Moisture, NA

Angle/Repose 1" Drop @ 8.9 % Moisture, 42° Angle Slide Steel Plate @ 8.9 % Moisture, 37º @

Apparent Cohesion PSF @ % Moisture, NA Bulk Density PCF

Angle/Repose 10" Drop 8.9 % Moisture, 340 Angle Internal Friction 8.8 % Moisture, 28°



PCT. BY WT. AND SHAPE BETWEEN SCREENS MUCK:

SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, some chert nedules, occasional clay partings. High strength. RQD (Est.) 100%. DUW: 160 PCF. Ground water: Minor. Hardness: Shore 46.

TBM, Alkirk hardrock, 13'8" dia. 28 Lawrence TCB roller, disc, tricone cutters. RPM: Center 30, head 9. Torque: 206 K ft #. Thrust: 540 K #. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LAW-4 Sheet 2

Lithology: Sedimentary, limestone, gray, fine grained, horizontal joint spacing 6" to 1'.

Umaxial Compressive Strength: 36 KPSI.

RQD: (Lstimated) 85% Dry Unit Weight: 166 PCF.

Ground Water: Minor, in fault zones.

Hardness: NA

# TUNNEL DATA:

Size: 11'-2" round. Grade: (+) .2%.

Ventilation System: 4 KCFM, exhaust, 18" pipe, 25 HP. Utility System: 6" air line, 1" water line, 6" pump line.

Water Inflow: 5-10 gpm. Power System: 4680/440V.

Haulage System: Muck, supplies, personnel, rail cars, 5 ton motors, track gage 24".

Support System: 4" H rings sets in fault zones, occasional pinned steel lagging.

### **EXCAVATION DATA:**

Machine: Jarva Mark 11-1100. Total weight: 65 tons.

Cutters: 27 Reed steel triple disc and cone. Gage: 4-CK5 steel disc.

Center: 1-QKl steel cone. Interior: 22-QK3 steel disc.

Rotation: Cutterhead RPM 9.3. Corque: Maximum 170 K ft#.

Thrust: 1, 104 K# maximum, 596 K #-operating. Anchor Pressure: 1, 650 K#.

Muck Collection: Bucket from face to 18" belt to 24" belt on gantry.

Power System: 440 volt, 6-50 HP motors drive head and 1-40 HP motor for hydraulic system.

Guidance: Laser.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. MIL-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material

Spec. Gravity, Material Size (-) 0.75": 2.89

Size (-) 0. 056": 0

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 16.90% Plasticity Index 1.21 %

Plastic Limit 15.69 % Toughness Index 0.24 %

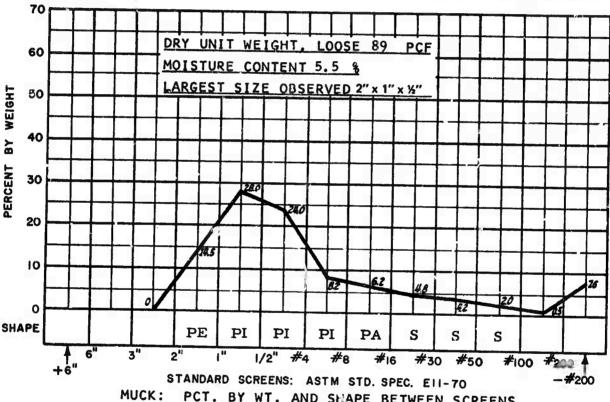
Shrinkage Limit 15.46 % Flow Index 5.00 %

MATERIAL SIZE (-)2.0 IN.

Angle/Repose 1" Drop @ 2.5 % Moisture, 36° Angle Slide Steel Plate 2.5 % Moisture, 30°

Apparent Cohesion PSF @ 4.1 % Moisture, 95 Bulk Density PCF @ 0.0 % Moisture, 86

Angle/Repose 10" Drop @ 2.5 % Moisture. 35° Angle Internal Friction @ 3.5 % Moisture, 35°



MUCK: PCT. BY WT. AND SMAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, horizontal joint spacing 6" to 1'. Strength: Very high. RQD (Est.) 85%. DUW: 166 PCF. Ground water: Minor. Hardness: NA.

System Class: TBM, Jarva Mark 11-100, 11'2" dia. 27 Reed triple disc cutters/cone. RPM: 9.3. Torque: 170 K ft #. Thrust: 596 K #. Mucking: Bucket to belt. Haulage: Rail. Support: H ring sets in fault zones.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MIL-1 Sheet 2

Lithology: Sedimentary, limestone, gray, fine grained, horizontal joint spacing 6" to 1".

Uniaxial Compressive Strength: 36 KPSI.

RQD: (Estimated) 85% Dry Unit Weight: 166 PCF.

Ground Water: Minor, in fault zones.

Hardness: NA

# TUNNEL DATA:

Size: 11'2" round, Grade: (+) .2%.

Ventilation System: 4KCFM, exhaust, 18" pipe, 25 HP. Utility System: 6" air line, 1" water line, 6" pump line.

Water Inflow: 5-10 gpm. Power System: 4680/440V.

Haulage System: Muck, supplies, personnel, rail cars, 5 ton motors, track gage 24".

Support System: 4" H rings sets in fault zones, occasional pinned steel lagging.

### **EXCAVATION DATA:**

Machine: Jarva 11-1100, Total weight: 65 tons.

Cutters: 27 Reed steel triple disc and cone. Gage: 4-QK5 steel disc.

Center: 1-QKl steel cone. Interior: 22-QK3 steel disc.

Rotation: Cutterhead RPM 9.3. Torque: Maximum 170 K ft. #.

Thrust: 1,104 K# maximum, 596 K#-operating Anchor Pressure: 1,650 K#.

Muck Collection: Bucket from face to 18" belt to 24" belt on gant, y.

Power System: 440 yelt 6-50 HP meters drived a land of the land.

Power System: 440 volt, 6-50 HP motors drive head and 1-40 HP motor

for hydraulic system.

Guidance: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MIL-2 Sheet 1

Abrasiveness

Pot. Vol. Change, Material Size (-) 0. 056": 0

Spec. Gravity, Material Size (-) 0.75":

N. A.

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 20.10% Plasticity Index 3.42%

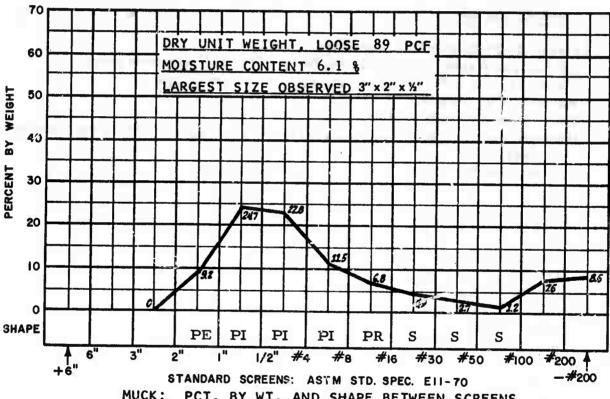
Plastic Limit 16.68 % Toughness Index 0.56% Shrinkage Limit 16.37 % Flow Index 6.10 %

# MATERIAL SIZE (-) 2.0 IN.

0.0 % Moisture, 90

Angle/Repose 1" Drop @ 5.8 % Moisture, 32° Angle Slide Steel Plate @ 5.8 % Moisture, 30° Apparent Cohesion PSF 5.0 % Moisture, 110 Bulk Density PCF

Angle/Repose 10" Drop @ 5.8 % Moisture, 30 Angle Internal Friction @ 5.0 % Moisture, 33°



PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, horizontal joint spacing 6" to 1'. Strength: Very high. RQD (Est.) 85%. DUW: 166 PCF. Ground water: Minor. Hardness: NA.

TBM, Jarva Mark 11-100, 11'2" dia. 27 Reed triple disc cutters. System Class: RPM: 9.3. Torque: 170 K ft #. Thrust: 596 K #. Mucking: Bucket to belt. Haulage: Rail. Support: H ring sets in fault zones.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MIL-2 Sheet 2

Lithology: Sedimentary, limestone, grey, fine grained, horizontal joint

was a state of the

4

spacing 4"-8".

Uniaxial Compressive Strength: 24K PSI.

RQD: (Estimated) 81%.

Dry Unit Weight: 164 PCF

Ground Water: Dry.

Hardness: NA.

### TUNNEL DATA:

Size: 11' 2" diameter. Grade: (+) 0.2%.

Ventilation System: 4 KCFM, exhaust, 25 HP (through bore hole).

Utility System: 6" air line, 1" water line, 6" pump line.

Water Inflow: Minor.
Power System: 4680/440V.

Haulage System: Muck, supplies, personnel by railcars, 5 ton locomotive,

24" gage.

Support System: None.

### **EXCAVATION DATA:**

Machine: Jarva, 11-1100, total weight 65 tons.

Cutters: 27 Reed steel disc: 4 gage QK5, 22 interior 2K3, 1 center QK1.

Rotation: 9.3 RPM. Torque: 119K ft. lbs.

Thrust: 639K#

Muck Collection System: Buckets from face, belt to rear.

Power System: 6-50 HP motors drivehead, 1-40 HP motor for hydraulic

system.

Guidance: Laser.

MDN STUDY 9/1/72 SYSTEM DATA SHELT MDN

Ident. No. MIL-3
Sheet 1

1 3 2 2 2 2

Abrasiveness N. A.

Pot. Vol. Change, Material Size(-) 0. 056" : 0

Spec. Gravity, Material Size (-)0.75": 2.78

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 15.20%

Plastic Limit 14. 40 % Plasticity Index 0.80 % Toughness Index 0.22 %

Shrinkage Limit 12.96 % Flow Index 3.50 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop Angle Slide Steel Plate

Apparent Cohesion PSF 2.5 % Moisture, 36° @ 2.3 % Moisture, 60 Bulk Density PCF

Angle/Repose 10" Drop @ 2.5 % Moisture. 32° Angle Internal Friction @ 2.3 % Moisture, 36°

2.5 % Moisture, 32°

@ 0.0 % Moisture, 95

DRY UNIT WEIGHT, LOOSE 79 PCF 60 MOISTURE CONTENT 5.1 % LARGEST SIZE OBSERVED 4"x 1%" x %" BY WEIGHT 50 40 PERCENT 30 25.4 20 /24 10 0 SHAPE PE PI PI PA 1/2" #4 #16 #100 #200 4 STANDARD SCREENS: ASTM STD. SPEC. E11-70 -#200

MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREEMS

### SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, horizontal jointing 4"-8". High strength. RQD: 81%. DUW: 164 PCF. Ground water: Drv. Hardness: NA.

System Class: TBM, Jarva 11-1100, 11'2" dia. 27 Reed disc cutters. 9.3 RPM, 119 K ft Torque, 639 K # Thrust. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. MIL-3 Sheet 2

Lithology: Sedimentary, limestone, light grey, fine grained.

Uniaxial Compressive Strength: 26K PSI.

RQD: 100%.

Dry Unit Weight: 168 PCF

Ground Water: Dry.

Hardness: NA.

# TUNNEL DATA:

Size: 10' 4" diameter. Grade: (+) 0.2%.

Ventilation: 18 KCFM, exhaust, 30" diameter pipe, 90 HP @ 1980'.

Utility System: 3" water line. Water Inflow: 300/400 gpm. Power System: 7200/480V.

Haulage System: Muck, supplies, personnel by railcars, 5 ton locomotive,

4 CY cars, 24" gage, 54# rail.

Support System: None.

# EXCAVATION DATA:

Machine: Robbins 105-144. Total weight: 75 tons.

Cutters: 26 Robbins, 12" and 11" discs. 2 Gage and 21 interior, 12" diameter,

3 center, 11" diameter.

Rotation: 6 RPM. Torque: 280K ft. lb. Thrust: 230K lb.

Muck Collection System: Buckets from face, belt to rear.

Power System: 4-100 HP motors drivehead, 50 HP for hydraulic system.

Guidance: Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. EVG-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material

Spec. Gravity, Material Size (-) 0.75": 2.81

Size (-)0.056" : 0

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 15.10%

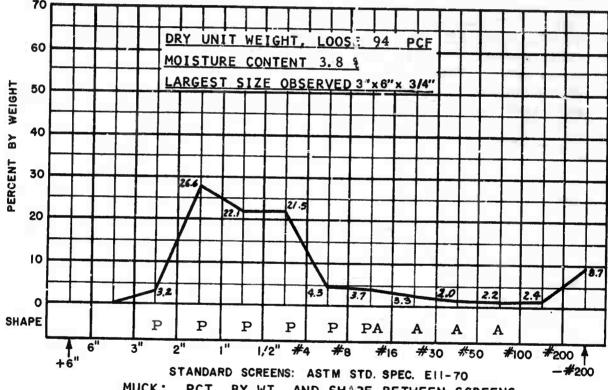
Plastic Limit 13.69% Plasticity Index 1.41% Toughness Index 0.47% Shrinkage Limit 11.57% Flow Index 3.0 %

# MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop 3.1 % Moisture, 37° Angle Slide Steel Plate 3.1 % Moisture, 31°

Apparent Cohesion PSF 3.0 % Moisture, 70 Bulk Density PCF @ 0.0 % Moisture, 104

Angle/Repose 10" Drop 3.1 % Moisture. 310 Angle Internal Friction 3.0 % Moisture, 420



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

### SUMMARY

Rock Class: Sedimentary: Limestone fine grained. High strength. RQD 100%. DUW: 168 PCF. Ground water: Dry. Hardness, NA.

System Class: TBM, Robbins, 105-144, 10' 4" dia. 26 Robbins disc cutters. RPM: 6. 280 K ft # torque, 230 K # thrust. Mucking: Buckets tc belt. Haulage: Rail. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. EVG-1 Sheet 2

Lithology: Sedimentary, limestone, light grey, fine grained.

Uniaxial Compressive Strength: NA.

**RQD: 100** 

Dry Unit Weight: NA. Ground Water: Dry.

Hardness: NA.

# TUNNEL DATA:

Size: 10' 4" diameter. Grade: (+) 0.2%.

Ventilation System: 18 KCFM, exhaust, 30" diameter pipe, 90 HP.

Utility System: 3" water line. Water Inflow: 300/400 gpm. Power System: 7200/480 V.

Haulage System: Muck, supplies, personnel by railcars, 5 ton locomotive,

4 CY cars, 24" gage, 54# rail.

Support System: None.

### **EXCAVATION DATA:**

Machine: Robbins 105-144. Total weight: 75 tons.

Cutters: 26 Robbins 12" and 11" discs, 2 gage and 21 interior-12" diameter

3 center-11" diameter.

Rotation: 6 RPM. Torque: 246K ft. l's. Thrust: 267K lb.

Muck Collection System: Buckets from face, belt to rear.

Power System: 4-100 HP motors drivehead, 50 HP for hydraulic system.

Guidance: Laser.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. EVG-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size : NA

Spec. Gravity, Material Size : NA

ATTERBERG LIMITS, MATERIAL SIZE

Liquid Limit NA %
Plasticity Index NA

Plastic Limit NA %
% Toughness Index NA %

IN.
Shrinkage Limit NA %
Flow Index NA %

MATERIAL SIZE

IN.

Angle/Repose 1" Drop Ap @ % Moisture, NA @ Angle Slide Steel Plate Bu @ % Moisture, NA @

Apparent Cohesion PSF
@ % Moisture, N/A
Bulk Density PCF

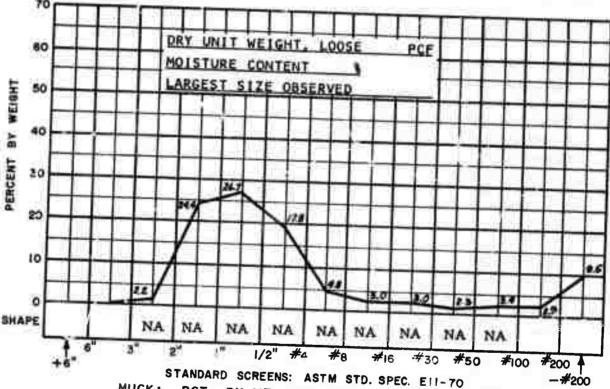
% Moisture, NA

Angle/Repose 10" Drop

@ % Moisture, NA

Angle Internal Friction

@ % Moisture, NA



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

RQD: 100%. Sedimentary: Limestone, fine grained. Strength: NA. Bullet NA. Ground water: Dry. Hardness: NA.

System Class: TBM Robbins 105-144. 10'-4" dia. 26 Robbins disc cutters. RPM: 6. Torque: 246 K ft #. Thrust: 267 K #. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 9/1/72

SYSTEM DATA SHEET
MDN

Ident. No. EVG-2 Sheet 2

Lithology: Sedimentary, sandstone, medium grained, light brown to red, massive, porous, poorly cemented.

Uniaxial Compressive Strength: 10 KPSI

RQD: (Estimated) 84%
Dry Unit Weight: 150 PCF
Ground Water: Generally dry.

Hardness: NA

# TUNNEL DATA:

Size: 12'-11" diameter. Grade: (+) .125%

Ventilation System: 15-17 KCFM exhaust, 36" dia. pipe, 100 HP @ 4100".

Utility System: 3 1/2" water line, 6" air line, 8" pump line.

Water Inflow: 20-100 gpm. Power System: 7300/480V

Haulage System: Muck, supplies, personnel, 10 ton locomotives, 10 CY

cars, 24" gage, 65 lb. rail.

Support System: 4" H full rings, 4' centers: 35%; 13" x 9' pans 3/4" x 7' rock bolts: 10%.

### **EXCAVATION DATA:**

Machine: Robbins 141-127, total weight: 125 tons.

Cutters: 32 Robbins steel disc. Cage: 6-12". Center: 1-11" triple disc. Interior: 23-11".

Rotation: Center cutter integral with head, 5.2 or 2.6 RPM.

Torque: 472 to 524 K ft. #.

Thrust: 331 K# to 382 K#. operating. Anchor pressure: 1,000 K#.

Muck Collection: Pickup by buckets fixed to head, discharging on 30" belt to a 24" x 204' belt on gantry.

Power System: 6-480/240V electric motors drive head. Hydraulic pumps power thrust and gripper cylinders.

Guidance System: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LAY-1 Sheet 1

Abrasiveness N. A. Pot. Vol. Change, Material Size (-)0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.66

# ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 21.20% Plasticity Index 3.14 %

Plastic Limit 17.06 % Toughness Index 0.52 % Shrinkage Limit 15.17 % Flow Index 6.00 %

# MATERIAL SIZE (-) 2.0 IN.

Angle/kepose 1" Drop

@ 3.6 % Moisture, 37°

Angle Slide Steel Plate

@ 3.6 % Moisture, 27°

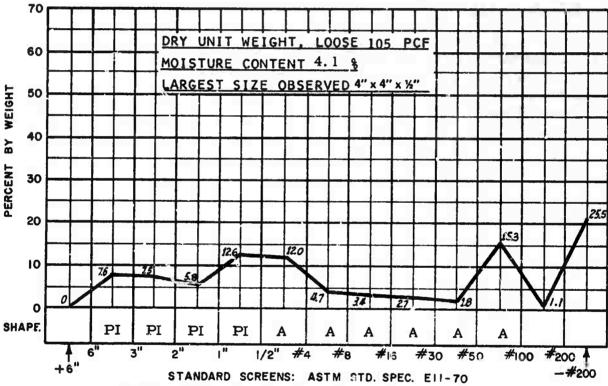
Apparent Cohesion PSF

@ 3.6 % Moisture, 210

Bulk Density PCF

0.0 % Moisture, 97.4

Angle/Repose 10" Drop @ 3.6 % Moisture, 35° Angle Internal Friction @ 3.6 % Moisture, 38°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Sedimentary: Sandstone, medium grained, massive, porous, poorly cemented. Strength: Medium. RQD (Est.) 84%. DUW: 150 PCF. Ground water: Dry. Hardness: NA.

System Class: TBM, Robbins 141-127, 12'11" lia. 32 Robbins disc cutters. RPM: 5.2. Torque: 498 ft #av. Thrust: 357 K # av. Mucking: Buckets to belt conveyor. Haulage: Gantry conveyor to rail cars. Support: Steel ring sets, 35%, rcof pars and rock bolts, 10% of 4100'.

MDN STUDY 9,1/72

SYSTEM DATA SHEET MDN

Ident. No. LAY-1 Sheet 2

Lithology: Sedimentary, conglomerate, well graded cobbles to pebbles of quartzite poorly to well cemented with reddish brown sandstone.

Uniaxial Compressive Strength: NA.

RQD: (Estimated) 85%. Dry Unit Weight: NA. Ground Water: Iry. Hardness: NA.

ID-CITYA A

# TUNNEL DATA:

Size: 12' 11" diameter. Grade: (+) 0.125%.

Ventilation System: 15-17 KCFM, 36" diameter pipe, 100 HP Utility System: 3 1/2" water line, 6" air line, 8" pump line.

Water Inflow: 20-100 gpm. Power System: 7300/480V.

Haulage System: Muck, supplies, personnel by railcar 10 ton locomotive,

10 CY cars, 24" gage 65# rail.

Support System: 4" H full rings in bad ground.

### **EXCAVATION DATA:**

Machine: Robbins 141-127. Total weight: 125 tons.

Cutters: 30 Robbins steel disc, gage 6-12", center 1-11" triple disc

interior 23-11".
Rotation: 5.2 RPM.
Torque: 490.7K ft. lb.
Thrust: 585.2K lb.

Muck Collection: Buckets from face, belt to rear.

Power System: 6-100 HP motors drivehead.

Guidance: Laser.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. LAY-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0. 056": 0

Spec. Gravity, Material Size (-) 0.75":

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 15.00% Plasticity Index 0.82 %

Plastic Limit 14.18% Toughness Index 0.21 %

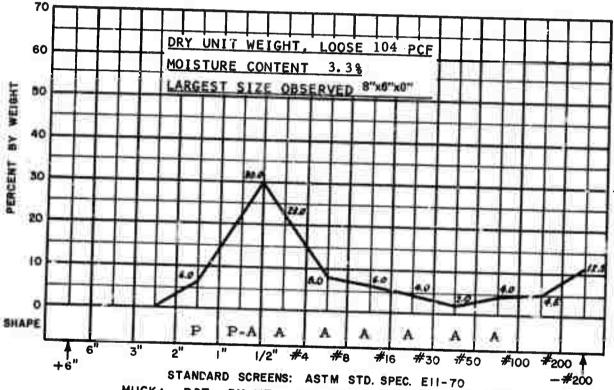
Shrinkage Limit 13.80 % Flow Index 4.00 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 3.4 % Moisture, 160 Angle Slide Steel Plate 3.4 % Moisture, 320

Apparent Cohesion PSF 3.0 % Moisture, 15 Bulk Density PCF 0.0 % Moisture, 88

Angle/Repose 10" Prop 3.4 % Moisture, 320 Angle Internal Friction 3.0 % Moisture, 390



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Sedimentary: Conglomerate, quartzite cobbles grading to pebbles, poorly to well cemented with sandstone. Strength: NA: RQD (Est.) 85%. DUW: NA. Ground water: Dry. Hardness: NA.

System Class: TBM Robbins 141-127. 32 Robbins disc cutters. RPM: 5.2 Torque: 491 K ft #. Thrist: 585 K #. Mucking: Buckets to belt. Haulage: Rail. Support: Rock bolts, normal, ring sets in bad ground.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. LAY-2 Sheet 2

Lithology: Sedimentary, siltstone, fine grained, gray, more than 33% quartz, 30% clay, 10% feldspar, 15% mica, chlorite and gypsum.

Uniaxial Compressive Strength: 2 KPSI

RQD: (Estimated) 70%

Dry Unit Weight: 142 PCF

Ground Water: Table above tunnel but sealed off by overlying beds.

Hardness: NA

### TUNNEL DATA:

Size: 20.5' round, Grade: (+).05%

Ventilation System: 18 KCFM exhaust 30" pipe, 60 HP.

Utility System: 6" air line, 4" pump line

Water Inflow: 50 GPH.

Power System: 4160/440V, rectified to 440 DC for head drive motors.

Haulage System: Muck, supplies, personnel, by 16 CY cars, 15 ton motor, 24" gage 70 lb rail.

Support System: Rock bolts, 8' and 10' x 3/4", set in epoxy with 5' and 13' x 16 gage pans, whoterete placed to prevent air slacking.

### EXCAVATION DATA:

Machine: Dresser TB-205, total weight: 200 tons

Cutters: 36 Dresser steel and TCB insert discs, 32 Kennametal U43 and U44 "pick" bits. Gage: 6-#9T5TD1 TCB insert discs. Center: 6-U43TC bits mounted a ound a 4" chisel. Interior: 30 Type STD steel discs and 26 U44 TC bits mounted on 4 bit blocks.

Rotation: 0-6 RPM range, 5 RPM normal operating.

Torque: Maximum 879 K ft. #., normal operating 586 K ft. #.

Thrust: Maximum 1,583 K # operating 431 K #.

Anchor Pressure: Maximum 6,616 K#.

Muck Collection: Buckets from face to 36" belt to 36" belt on 140' gantry. Power System: Four 180 HP D. C. head motors, one 75 HP for hydraulic system.

Guidance System: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NAV-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056": 1.3

Spec. Gravity, Material Size (-)0.75": 3.13

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 36.80%

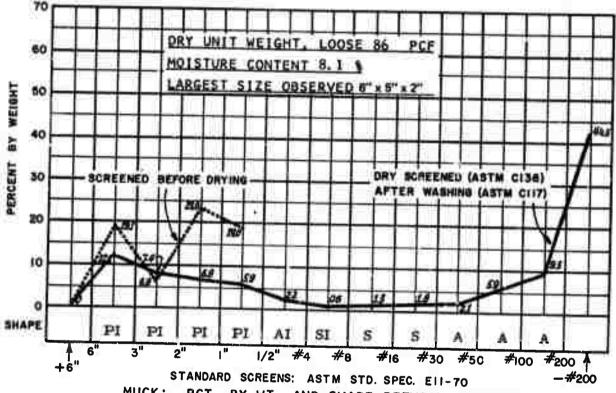
Plastic Limit 23.61% Plasticity Index 13.1% Toughness Index 1.88% Shrinkage Limit 21.04 % Flow Index 7.00%

MATERIAL SIZE (-)2.0 IN.

Angle/Repose 1" Drop 7.7 % Moisture, 30° Angle Slide Steel Plate 7.7 % Moisture, 300

Apparent Cohesion PSF @ 7.5 % Moisture, 340 Bulk Density PCF @ 0.0 % Moisture, 98

Angle/Repose 10" Drop 7.7% Moisture, 30° Angle Internal Friction 7.5 % Moisture, 36°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

### SUMMARY

Rock Class: Sedimentary: Siltstone, fine grained. Strength: Very low. RQD (Est.) 70%. DUW: 142 PCF. Ground water: Minor. Hardness: NA.

TBM, Dresser TB 205, 20.5' dia., Dresser disc cutters: System Class: 6TCB and 30 steel, 32 Kennametal, TCB "pick" bits. RPM: 5, 586 K ft #. Torque: 431 K # thrust. Mucking: Buckets to belt. Haulage: Rail. Support: Roof plates and rock bolts, at 3' or 4', continuous.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. NAV-1 Sheet 2

Lithology: Sedimentary, sandstone, gray, medium grained, massive, friable and porous. Grains angular to subrounded, primarily quartz, poorly cemented.

Uniaxial Compressive Strength: Less than 1 KPSI, disintegrates when wet.

RQD: (Estimated) 60%

Dry Unit Weight: 117 PCF

Ground Water: Table above tunnel but sealed off by overlying beds.

Hardness: NA

### TUNNEL DATA:

Size: 20.5' diameter. Grade: (+).05%

Ventilation System: 18 KCFM exhaust, 30" pipe, 60 HP.

Utility System: 6" air line, 4" pump line

Water Inflow: 50 GPH.

Power System: 4160/440V, rectified to 440 DC for head drive motors.

Haulage System: Muck, supplies, personnel, by 16 CY cars, 15 ton motor, 24" gage 70 lb rail.

Support System: Rock bolts, 8' and 10' x 3/4", set in epoxy, with 5' and

13' x 16 gage pans, shotcrete placed to prevent air slacking.

### **EXCAVATION DATA:**

Machine: Dresser TB-205, total weight: 200 tons

Cutters: 36 Dresser steel and TCB insert discs, 32 Kennametal U43 and U44 "pick" bits. Gage: 6-#9T5TD1 TCB insert discs. Center: 6-U43TC bits mounted around a 4" chisel. Interior: 30 Type STD steel discs and 26 U44TC bits mounted on 4 bit blocks.

Rotation: 0-6 RPM range, 5 RPM normal operating.

Torque: Maximum 879 K ft. #., normal operating 586 K ft. #.

Thrust: Maximum 1,583 K #. operating 123 K #.

Anchor Pressure: Maximum 6,616 K #.

Muck Collection: Buckets from face to 36" belt to 36" belt on 140' gantry. Power System: Four 180 HP D.C. head motors, one 75 HP for hydraulic system.

Guidance System: Laser

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. NAV-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.751: 2.72

# ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.20% Plasticity Index 1.29 %

Plastic Limit 16.91% Toughness Index 0.28% Shrinkage Limit 16.60 % Flow Index 4.50 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop

@ 8.6% Moisture, 31°

Angle Slide Steel Plate

@ 8.6% Moisture, 32°

Apparent Cohesion PSF

@ 8.1% Moisture, 45

Bulk Density PCF

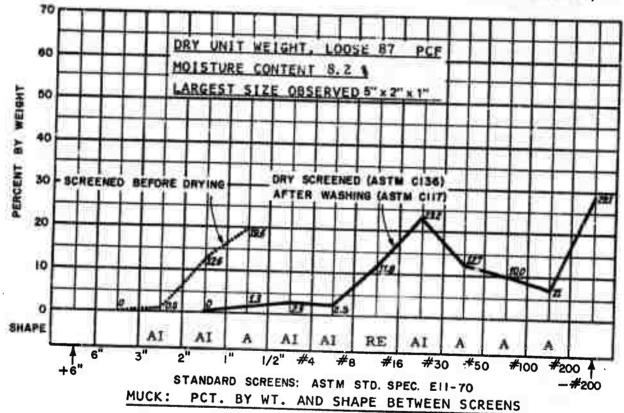
@ 0.0% Moisture, 99

Angle/Repose 10" Drop

@ 8.6 % Moisture, 28°

Angle Internal Friction

@ 8.1 % Moisture, 28°



SUMMARY

Rock Class: Sedimentary: Sandstone, massive, friable, porous, medium grained. Very low strength. RQD (Est.) 60%. DUW: 117 PCF. Ground water: Minor. Hardness: NA.

System Class: TBM, Dresser TB 205, 20.5' dia. Dresser, disc cutters 6TCB and 30 steel, 32 Kennametal, TCB "pick" bits. RPM: 5, 586 K ft # torque, 123 K # thrust. Mucking: Buckets to belt. Haulage: Rail. Support: Roof plates and rock bolts, at 3' or 4', continuous.

MDN STUDY

SYSTEM DATA SHEET MDN

Ident. No. NAV-2 Sheet 2

0/1/72

Lithology: Sedimentary, sandstone, fine grained, brown to dark red massive.

Uniaxial Compressive Strength: NA.

RQD: 60%.

Dry Unit Weight: NA:

Ground Water: Generally dry.

Hardness; NA.

### TUNNEL DATA:

Size: 18' 4" diameter. Grade: +. 045%.

Ventilation System: 22 KCFM, exhaust, 48" diameter pipe, 2-150 HP

Utility System: 8" air line, 4" water line, 8" pump line.

Water Inflow: 40 gpm.

Power System: 13200/440V.

Haulage System: Muck, supplies, personnel by railcars, 15 ton locomotive

10 CY cars, 36" gage, 50# rail.

Support System: Rock bolts, 5', 6', 8' x 5/8", 24" centers, 14 gauge pans

12' 6" or 8' 6" x 8".

### **EXCAVATION DATA:**

Machine: Lawrence HRT. Total weight: NA.

Cutters: 32 Lawrence Mfg Tungsten Carbide Button, roller, disc and tricone.

Gage: 5 TCB roller, Interior 24 disc and 2 TCB roller, center 1-24"

TCB tricone.

Rotation: Head 11 RPM, center 30 RPM.

Torque: Center cutter 150 HP, head 750 HP, 364K ft. lb.

Thrust: 492K lbs.

Muck Collection: Buckets from face discharging to 24" belt.

Power System: Electro-Hydraulic. Total HP: 960

Guidance System: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. RO-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size NA:

Spec. Gravity, Material Size NA:

ATTERBERG LIMITS, MATERIAL SIZE

IN.

Liquid Limit NA %
Plasticity Index NA %

Plastic Limit NA % Toughness Index NA % Shrinkage Limit NA % Flow Index NA %

MATERIAL SIZE

@

IN.

Angle/Repose 1" Drop
@ % Moisture, NA
Angle Slide Steel Plate
@ % Moisture, NA

Apparent Cohesion PSF @ % Moisture, NA Bulk Density PCF

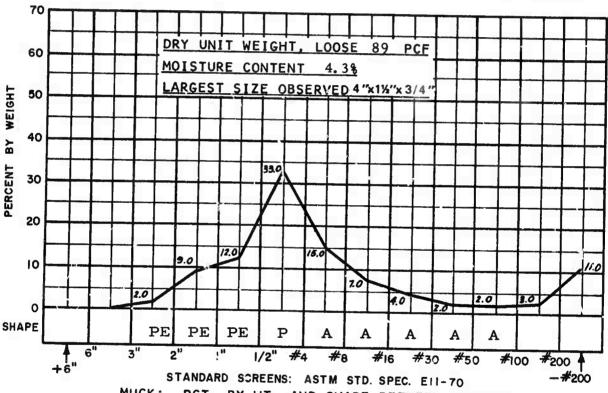
% Moisture, NA

Angle/Repose 10" Drop

@ % Moisture, NA

Angle Internal Friction

© % Moisture, NA



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

### SUMMARY

RQD: 60%. DUW: NA. Ground water: Dry. Hardness: 32, schmidt.

System Class: TBM Lawrence HRT 18' 4" dia. 32 Lawrence button roller, disc cutters. 11 RPM head, 30 RPM center. 364 K ft # torque. 492 K # thrust. Mucking: Buckets to belt. Haulage: Rail. Support: Rock bolts 24" centers.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. RO-1 Sheet 2

Lithology: Sedimentary, sandstone, coarse grained, poorly consolidated, arkosic, with minor layers of thin seamed silts one.

Uniaxial Compressive Strength: 50 to 150 PSI dry-disintegrates when wet.

RQD: (Estimated) 30%. Dry Unit Weight: 125 PCF.

Ground Water: Saturated when first opened.

Hardness: NA

### TUNNEL DATA:

Size: 10' high by 8' wide, rectangular. Grade (+) 1/2%.

Ventilation System: 5 to 7 KCFM, pressure, 18" dia. vent tube.

Utility System: 4" airline. Water Inflow: 20-25 gpm.

Power System: 440/110V, trailing cable.

Haulage System: Muck, personnel and supplies by rail cars, 24" gage,

40# rail.

Support System: None, rock bolts and/or shotcrete in bad ground.

# **EXCAVATION DATA:**

Machine: Alpine Miner, Type F6-A. Total Weight: 11 tons.

Cutters: 72, Kennametal U43K, Carbide tipped, "pick" type. Cutters, mounted on twin ripper heads, rotating about a horizontal axis at 900 to a boom which moves the heads vertically and horizontally.

Rotation: 60 RPM, motor and gear box integral with boom.

Torque: 50.4 HP

Thrust: Sumping thrust from crawler motors, 2 @ 20.4 HP. Vertical and horizontal by hydraulic cylinders powered by a 10.4 HP electro-hydraulic system.

Anchor Pressure: Crawlers only.

Muck Collection: Central 14" chain conveyor, fed by gathering arms, discharges on an 18" x 30' belt feeding 116' of 20" Serpentix conveyor. Transverse folds are molded into 20" x 8" long rubber Serpentix sections, which are bolt connected at reinforced flanges connected to an endless chain driven by a sprocket. Folds allow inside edge to compress and outside to expand on curves. Vertebral side rail sections, alternating with straight sections, are supported by wheeled gantry legs riding a 60" gage track, under which cars are spotted.

Power System: 440V, trailing cable. Guidance System: Transit/Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. WNG-1 Sheet 1

Abrasiveness

Pot. Vol. Change, Material

Spec. Gravity, Material

N. A.

Size (-) 0.056": 0

Size (-) 0.75": 2.71

### ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

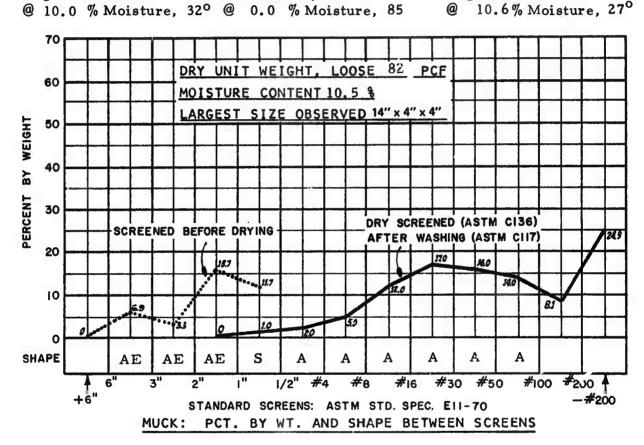
Liquid Limit 24.90% Plasticity Index 4.93% Plastic Limit 19.97% Toughness Index 0.66% Shrinkage Limit 19.94 % Flow Index 7.40%

### MATERIAL SIZE (-)2.0 IN.

Angle/Repose 1" Drop @ 10.1 % Moisture, 34° Angle Slide Steel Plate

Apparent Cohesion PSF @ 10.6 % Moisture. 0 Bulk Density PCF

Angle/Repose 10" Drop @ 10.1 % Moisture. 31° Angle Internal Friction



SUMMARY

Sedimentary: Sandstone, coarse grained, poorly consolidated, arkosic, minor thin seamed siltstone. Very low strength. RQD (Est.) 30%. DUW: 125 PCF. Ground water: Saturated. Hardness: NA.

TBM, Alpine F6A, twin head, 10' high x 8' heading. 72 Kennametal System Class: TCB pick type bits. 60 RPM, 50.4 HP head torque, 10.4 HP boom power, 40.8 HP sumping thrust. Mucking: Gathering arms-flight conveyor. Haulage: Elevating conveyor - Serpentix conveyor on gantry - rail cars. Support: Normally none.

MDN STUDY

SYSTEM DATA SHEET

Ident. No. WNG-1

9/1/72

MDN

Sheet 2

Lithology: Sedimentary, sandstone, coarse grained, poorly consolidated, arkosic, with minor layers of the seamed siltstone, varying concentrations of replacement silica.

Uniaxial Compressive Strength: 50 to 150 PSI dry-disintegrates when wet.

RQD: (Estimated) 30% Dry Unit Weight: 125 PCF

Ground Water: Saturated when first opened.

Hardness: NA

### TUNNEL DATA:

Size: 5' wide x 9' high, nominally rectangular. Grade: Varies.

Ventilation System: 5 to 7 KCFM, pressure, 18" vent tube.

Utility System: 2" air, 1" waterline.

Water Inflow: 20-25 gpm when levels are first opened; generally dry after drainage.

Power System: None in development headings, 440V to scraper hoists, 110V lighting.

Haulage System: Muck is scraped from the face of a cross cut to a slusher drift, cross scraped to a muck raise, and loaded into 4 cu. ft. rocker dump rail cars on main level about 80' below. Scrapers are 42", hoists 15 HP. Personnel access by ladder, supplies by rail cars and air-powered hoists through raises.

Support System: None. Rockbolts in bad ground.

### **EXCAVATION DATA:**

Conventional Scraper-Rail Haulage System.

Drilling: LeRoi Model 35 jackhammers mounted on 6' airfeed legs.

Drill Round: Five hole box or vertical line burn cut, 6' depth, included in 18 hole round, all holes 1 1/2" diameter.

Explosives: 50# Dupont 40% Galex #2, Powder factor: 5#/cu. yd.

Blasting: Safety fuse and caps.

Mucking System: 42" Scrapers, 15 HP hoists.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. WNG-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.075": 2.72

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 25.25% Plasticity Index 0.51 %

Plastic Limit 24, 74% Toughness Index 0.13 %

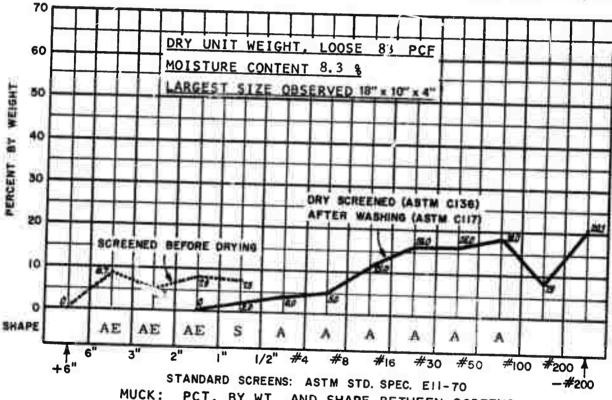
Shrinkage Limit 23.37 % Flow Index 4.00 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 9.0 % Moisture, 32° Angle Slide Steel Plate @ 9.0 % Moisture, 40°

Apparent Cohesion PSF 9.0% Moisture, 0 Bulk Density PCF 0.0% Moisture, 86

Angle/Repose 10" Drop 9.0% Moisture, 31° Angle Internal Friction 9.0% Moisture, 28°



PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Sedimentary: Sandstone, coarse grained, poorly consolidated, arkosic, minor thin seamed siltstone, varying replacement silica. Very low strength. RQD (Est.) 30%. DUW: 125 PCF. Ground water: Saturated. Hardness: NA.

System Class: Conventional Scraper-Rail. 5' wide x 9' high, rectangular. Airleg jackhammer, 18 - 6' holes, burn cut. PF 5#/CY. Mucking: Scraper to raise. Haulage: Rail cars - skip to surface. Support: Normally none.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. WNG-2 Sheet 2

Lithology: Sedimentary, sandstone, arkosic, irregularly

bedded, loosely consolidated with layers and lenses of silty mudstone.

Uniaxial Compressive Strength: Less than one KPSI.

RQD: (Estimated) 15% Dry Unit Weight: 113 PCF

Ground Water: Saturated; water table above tunnel, heading is drained in

advanced by lateral pilot holes in ribs.

Hardness: NA

### TUNNEL DATA:

Size: 21 ft., diameter. Grade: (+) 0.2%.

Ventilation System: 20 KCFM, 36" pipe, pressure at face, exhaust in

access.

Utility System: 6" air line, 6" pump line.

Water Inflow: 200 gpm. Power System: 4160/480V.

Haulage System: Muck, personnel, supplies by rail cars.

Support System: Continuous, precast concrete rings 8" and 10" thick,

erected in four-4' segments.

### EXCAVATION DATA:

Shield: Robbins 221S ripper, Total weight: 285 tons

Thrust: 3,500 tons total.

Muck Collection System: Muck is ripped from the face by a ripper tooth and drawn through the shield to a 6' conveyor by hydraulic ram with a bucket opposite the ripper tooth.

Power System: Hydraulic. Guidance System: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. SF-1 Sheet 1

#### MUCK DATA

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.065": 0

Spec. Gravity, Material Size (-)0.1851. 2.86

ATTERBERG LIMITS, MATERIAL SIZE (-)0.185 IN.

Liquid Limit 17.75% Plasticity Index 1.56 %

Plastic Limit 16.19% Toughness Index 0.27%

Shrinkage Limit 13.94 % Flow Index 5.8 %

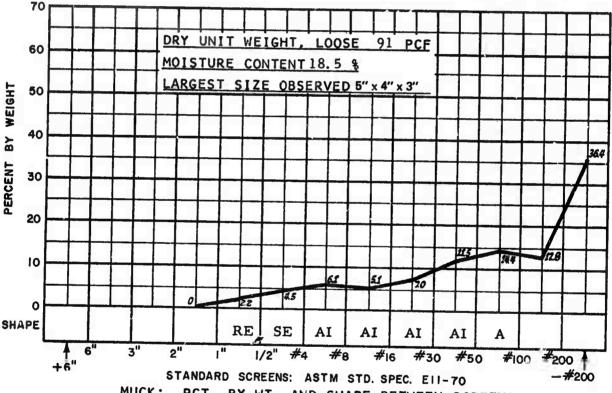
MATERIAL SIZE (-)0. 185IN.

Angle/Repose 1" Drop @ 14.3 % Moisture, 38° Angle Slide Steel Plate @ 12.5 % Moisture, 36° Apparent Cohesion PSF

@ % Moisture, NA
Bulk Density PCF

% Moisture, NA

Angle/Repose 10" Drop @ 14.3 % Moisture, 33° Angle Internal Friction @ 13.0 % Moisture, 42°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

#### SUMMARY

Rock Class: Sedimentary: Sandstone, arkosic, loosely consolidated, with layers and lenses of silty mudstone. Strength: Very low. RQD (Est.) 15%. DUW: 313 PCF. Ground water: Saturated. Hardness: NA.

System Class: Shield, Robbins 221S ripper, 21 dia. Thrust: 3500 tons. Mucking: Hydrau c boom operated bucket scraper to conveyor. Haulage: Rail. Support: Continuous, precast concrete ring segments.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. SF-1 Sheet 2

### ROCK DATA:

Lithology: Sedimentary, sandetone, biotite rich siltstone,

poorly to well consolidated, poorly to well sorted.

Uniaxial Compressive Strength: 2 KPSI

RQD: (Estimated) 50% Dry Unit Weight: 142 PCF

Ground Water: Sandstone saturated, water table above tunnel, heading

drained in advanced by lateral pilot holes in ribs.

Hardness: NA

### TUNNEL DATA:

Size: 21 ft., round, Grade: (+) 0.2 pct.

Ventilation System: 20 KCFM, 36" pipe, pressure at face, exhaust in

access.

Utility System: 6" air line, 6" pump line.

Water Inflow: 20 gpm Power System: 4160/480V

Haulage System: Muck, personnel, supplies by rail cars.

Support System: Continuous, precast concrete rings 8" and 10" thick,

erected in four 4' segments.

### **EXCAVATION DATA:**

Shield: Robbins 221S ripper, total weight: 285 tons.

Thrust: 3,500 tons total.

Muck Collection System: Muck is ripped from face by a ripper tooth and drawn through the shield to a 6' conveyor by hydraulic ram with a bucket opposite the ripper tooth.

Power System: Hydraulic Guidance System: Laser

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. SF-2 Sheet 1

#### MUCK DATA

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056": 0

Spec. Gravity, Material Size (-)0.0751: 3.02

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 31.5 % Plasticity Index 4.7 %

Plastic Limit 26.8 % Toughness Index 0.61 % Shrinkage Limit 21.5 % Flow Index 7.6 %

MATERIAL SIZE (-)1.0 IN.

Angle/Repose 1" Drop @ 15.1 % Moisture, 38° Angle Slide Steel Plate

Apparent Cohesion PSF

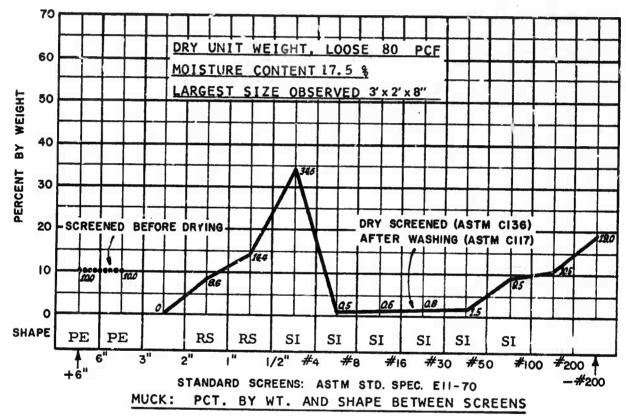
@ % Moisture, NA
Bulk Density PCF

Angle/Repose 10" Drop @ 15.1 % Moisture, 365 Angle Internal Friction

@ 15.1 % Moisture, 30°

@ % Moisture, NA

@ 15 % Moisture, 27°



#### SUMMARY

Rock Class: Sedimentary: Sandstone and siltstone, poorly to well consolidated. Strength: Very low. RQD (Est.) 50%. DUW: 142 PCF. Ground water: Saturated. Hardness: NA.

System Class: Shield, Robbins 221S ripper, 21' dia. Thrust 3500 tons. Mucking: Hydraulic boom operated bucket scraper to conveyor. Haulage: Rail. Support: Continuous, precast concrete ring segments.

MDN STUDY 9/1/72 SYSTEM DATA SHEET MDN

Ident. No. SF-2 Sheet 2

### ROCK DATA:

Lithology: Sedimentary, mudstone, dark gray, fine grained, massive.

Uniaxial Compressive Strength: 11 KPSI dry.

RQD: (Estimated) 90%.

Dry Unit Weight: 144 PCF.

Ground Water: Generally dry.

Hardness: NA

### TUNNEL DATA:

Size: 10' high x 9' wide (7'-6" top, 9'-6" bottom). Grade: (+) 1/2%. Ventilation System: 5 KCFM, exhaust from face, pressure to venthole, 16" flexhaust, 24" vent tube, 2-25 HP Axivane fans.

Power System: 440V trailing cable.

Haulage System: Muck, personnel and supplies by rail cars, 36" gage, 45# rail.

Support: 4" WF steel sets at 3' or 6'.

### **EXCAVATION DATA:**

Machine: Alpine Miner, Type F6-A. Total Weight: 11 tons.

Cutters: 40 Kennametal U43KH, Carbide tipped, "pick" type. Cutters mounted on twin ripper heads, rotating about a horizontal axis at 900 to a boom which moves heads vertically and horizontally.

Rotation: 78 RPM, motor and gear box integral with boom.

Torque: 50.4 HP.

Thrust: Sumping thrust from crawler motors, 2 @ 20.4 HP, vertical and horizontal by hydraulic cylinders powered by a 10.4 HP electro-hydraulic system.

Anchor Pressure: Crawlers only.

Muck Collection: Central 14" flight conveyor fed by two gathering arms mounted on an inclined apron, discharges on an 18" elevating conveyor loading rail cars.

Power System: 440V, trailing cable. Guidance System: Transit/Laser.

MDN STUDY 9/1/72

SYSTEM DATA SHEET MDN

Ident. No. KM-1 Sheet 1 MUCK DATA

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.87

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 28.30%

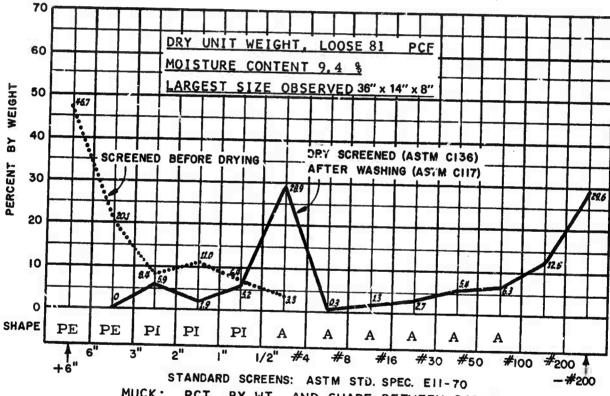
Plastic Limit 24.97 % Plasticity Index 3.33 % Toughness Index 0.92 % Shrinkage Limit 19.12 % Flow Index 3.60 %

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 12.7 % Moisture, 290 Angle Slide Steel Plate @ 12.7 % Moisture, 31° @ 0.0 % Moisture, 79

Apparent Cohesion PSF @ 10.9 % Moisture, 37 Bulk Density PCF

Angle/Repose 10" Drop @ 12.7 % Moisture, 28° Angle Internal Friction @ 10.9 % Moisture, 35°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Mudstone ("shale") fine grained, massive. Medium strength. RQD (Est.) 90%. DUW: 144 PCF. Ground water: Dry. Hardness: NA

System Class: TBM, Alpine F6A, twin head, 10' high x 9' heading. 40 Kernametal TCB pick type bits. 78 RPM, 50.4 HP head torque, 10.4 HP boom power, 40.8 HP sumping thrust. Mucking: Gathering arms - flight conveyor. Haulage: Elevating conveyor-rail cars. Support: Steel sets at 3' or 6', continuous.

MDN STUDY

SYSTEM DATA SHEET MDN

Ident. No. KM-1

Sheet 2

9/1/72

### APPENDIX D

### ALGORITHM DEVELOPMENT

In simple regression, it is supposed that with each observation value, there is another quantity which can be observed or somehow related to the observation. After n observations, there exists a series of pairs,  $(x_1, y_1)$ ,  $(x_2, y_2)$ ,  $\cdots$ ,  $(x_n, y_n)$ . The question we wish to answer is to determine if there is a relationship between y and x and how this relationship can be obtained.

One may assume that there is such a relationship, and that this relationship is linear. With this assumption, one may write

$$y = \alpha x + \beta \tag{1}$$

The  $x_i$ ,  $i=1,\cdots,n$ , are the values of the independent variable x, and the  $y_i$ ,  $i=1,\cdots,n$ , are the values of the dependent variable y.  $\alpha$  and  $\beta$  are the coefficients which will have to be determined from the observation points.

It is possible that a relationship exists between x and y, but the relationship is not linear. A possible alternate in this case is to find another variable,  $x^l$ , related to x, such that y can then be linearly related to  $x^l$ . The new variable  $x^l$  will then be used in place of x in the discussions that follow.

Assuming that the linear relationship is valid, we can create an error term which is the sum of the squares of all deviations of observed values from the linear Equation (1). Thus the error  $\epsilon$  is

$$\epsilon = \sum_{i=1}^{n} (y_i - (\alpha x_i + \beta))^2$$
 (2)

and determine  $\alpha$  and  $\beta$  so  $\epsilon$  is minimum. This simple regression is known as the method of "least squares". The solution can be shown to be:

$$\alpha = v_{xy}/s_x^2 \tag{3}$$

$$\beta = \overline{y} - \alpha \overline{x} \tag{4}$$

where

$$s_{x}^{2} = \frac{1}{n-1} \sum_{i=1}^{n} (x_{i} - \overline{x})^{2}$$
 (5)

$$\mathbf{v}_{\mathbf{x}\mathbf{y}} = \frac{1}{n-1} \sum_{i=1}^{n} (\mathbf{x}_{i} - \overline{\mathbf{x}}) (\mathbf{y}_{i} - \overline{\mathbf{y}})$$
 (6)

 $\overline{\mathbf{x}}$  and  $\overline{\mathbf{y}}$  are the arithmetic averages of the  $\mathbf{x}_i$  and  $\mathbf{y}_i$  respectively.

Equations (3) and (4) give the necessary coefficients in terms of observed values for the predictor Equation (1). If y had been the MDN, and x an in-situ rock property (or some transformation of it), then this simple regression would have resulted in a predictor equation for the MDN.

A procedure similar to the simple regression technique will be applicable if we want to relate a dependent variable y to several independent variables  $x_1, x_2, x_3, \cdots, x_{m-1}$ . (Note the  $x_1, x_2, \cdots, x_{m-1}$  are independent variable and not the observation points themselves). If n observations are taken, then one has the following sets of points:  $(y_1, x_1, 1, x_2, 1, x_3, 1, \cdots, x_{m-1}, 1), (y_2, x_1, 2, x_2, 2, x_3, 2, \cdots, x_{m-1}, 2), \cdots, (y_n, x_{1n}, x_{2n}, x_{3n}, \cdots, x_{m-1}, n)$ .

A linear relationship is assumed to exist between y and  $x_1, x_2, \cdots, x_{m-1,n}$ . Thus, one has

$$y = \alpha_0 + \alpha_1 x_1 + x_2 y_2 + \cdots + \alpha_{m-1} x_{m-1}$$
 (7)

The coefficients  $\alpha_0$ ,  $\alpha_1$ ,  $\dots$ ,  $\alpha_{m-1}$  will have to be determined from the n observations of the variables.

To solve for the coefficients requires the manipulation of certain arrays. Defining the following one dimensional arrays:

$$\alpha = \begin{pmatrix} \alpha_0 \\ \alpha_1 \\ \vdots \\ \alpha_{m-1} \end{pmatrix} \qquad ; \quad w = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}$$
 (8)

Let A be the two-dimensional array.

$$A = \begin{pmatrix} 1 & x_{1,2} & x_{2,1} & \cdots & x_{m-1,1} \\ 1 & x_{1,2} & x_{2,2} & \cdots & x_{m-1,2} \\ \vdots & & & \vdots \\ 1 & x_{1,n} & x_{2,n} & \cdots & x_{m-1,n} \end{pmatrix}$$
(9)

Define a vector error by:

$$z = w - A\alpha \tag{10}$$

The scalar error is:

$$\epsilon = z^{T}z = [w - A\alpha]^{T}[w - A\alpha]$$

$$= \alpha^{T}A^{T}A\alpha - (w^{T}A\alpha + \alpha^{T}A^{T}w) + w^{T}w$$
(11)

The derivative with respect to  $\alpha$  is:

$$\frac{\mathrm{d}\,\epsilon}{\mathrm{d}\alpha} = 2\mathrm{A}^{\mathrm{T}}\mathrm{A}\alpha - 2\mathrm{A}^{\mathrm{T}}\mathrm{w} \tag{12}$$

For minimum error,  $d\epsilon/d\alpha = 0$ , thus

$$\alpha = (A^T A)^{-1} A^T w \tag{13}$$

A<sup>T</sup> is the transpose of the matrix A given by Equation (9).

The general computational procedure is as follows:

- (1) Form the array A as given by Equation (9).
- (2) Obtain the transpose, A<sup>T</sup>, from A. This is just a matter of interchanging rows and columns.
- (3) Compute A<sup>T</sup>A, then (A<sup>T</sup>A)<sup>-1</sup>, then (A<sup>T</sup>A)<sup>-1</sup>A<sup>T</sup>. This involves a series of matrix multiplications and matrix inversion. These techniques are readily available from a computer.
- (4) Form the array w from Equation (8).

- (5) Multiply the result of Step (3) by the result of Step (4). This yields a set of coefficients  $\alpha_0$   $\alpha_1$ ,  $\cdots$ ,  $\alpha_{m-1}$ .
- (6) Test for goodness of fit or the quality of the predictor equation.

A basic assumption is that the predictor equation is linear, and that the independent variables to use are the observation variables themselves. It may be necessary to define another set of variables  $x_1'$ ,  $x_2'$ ,  $\dots$ ,  $x_{m-1}'$  so use in order to obtain a linear relationship.

It often happens that the independent variables are themselves related. If a linear relationship exists between any two of the independent variables,  $(A^TA)^{-1}$  will be singular, i.e.,  $A^TA$  will have zero determinant, and hence  $(A^TA)^{-1}$  cannot be computed. If this is so,  $\alpha$  is difficult to compute, and the standard errors of the calculated coefficients are huge, giving an inaccurate predictor equation. This problem can be circumvented by performing the regression analysis with one variable, then with two variables, etc. while being careful when this problem arises. One may combine linearly any two variables that are highly correlated and use the combined variable as in the independent variable.

Good computer routines exist which are available on most computers, including routines for matrix transpose, matrix multiplication and matrix inversion, together with standard routines to compute means and standard deviations of a set of observations. In fact, there also exists software that performs stepwise regression analysis, performing the above calculations plus multiple correction coefficients and residuals.

In multiple regression to predict an MDN, the MDN is treated as the dependent variable. The set of independent variables may include the following in situ rock properties.

- (a) Rock classification, quantified, e.g., as Igneous = 1, Metamorphic = 2, Sedimentary = 3
- (b) Compressive strength, Fc
- (c) Rock quality designation, RQD
- (d) Dry Unit Weight, DUW
- (e) Hardness, H
- (f) Ground Water, GW quantified, e.g., as Dry = 1, Minor = 2, Wet = 3

Additional parameters peculiar to the excavation method may also be included in the set of independent variables. Some of these variables may be excluded from the analysis; others still undefined may be included. The regression analysis may be performed using one or more of these variables.

A set of observations is obtained, and with each set of observations, an MDN is indicated. A table with the following entries will be created:

MDN	CLASS	Fc	RQD	DUW	<u>H</u>	_GW
		-				

It is seen that y corresponds to MDN, and CLASS, Fc, RQD, DUW, H, and GW, correspond to  $x_1, x_2, \cdots$ , and  $x_3$ , respectively. The matrix in Equation (9) corresponds to the observation points. The array in Equation (8) corresponds to the MDN indicated in column 1. The predictor equation may be obtained from Equation (13).

Several iterations of this analysis should be performed on the computer in order to determine which variable or combinations of variables are appropriate to include in the predictor equation. Certain tests can be performed to determine the quality and accuracy of this predictor equation. With computer routines readily available, several iterations may be performed with reasonable cost and in a very short time.

## APPENDIX E

# TRANSPORT SYSTEM SELECTION PARAMETERS

The following list of equipment capabilities, system constraints, and MDN applications is taken in part from Report No. FRA-RT-71-57, "Materials Handling for Tunnels," HN-8080, Holmes & Narver, Inc., and Resource Management Corporation, September 1970, prepared for the U. S. Department of Transportation, Washington, D.C., with additional details provided by the authors. With some differences, the list was incorporated as Section 3.6 of the Annual Technical Report of the first year's program. MDN applicability is based only on muck characteristics, and is subject to constraints imposed by such factors as tunnel size, grade and length, equipment and power cost and availability, and environmental considerations.

### UNITIZED SYSTEMS

## Conventional Rail Systems

## Capabilities and Advantages

Hauling capacities can be varied by the addition or removal of cars or trains.

Materials, supplies, and personnel can be transported by the system.

Easily adaptable to automatically controlled operation.

Loading and dumping can be done rapidly.

Track extension is relatively simple.

# System Constraints

A large percentage of tunnel cross section is occupied by equipment.

High speeds needed for short cycle time.

Ideal road bed and track conditions are necessary if delays cannot be tolerated.

Passing tracks are required in long tunnels.

A secondary system or assisted haulage is needed if vertical grade is over 4 percent.

Supply of materials required for system extension is a major operation at high advance rates.

Small clearances, high speeds, and massive moving equipment combine to produce long delays and serious injuries in event of accidents.

Combustion products complicate ventilation unless vehicles are powered electrically.

## Applicability

Applicable to any of the MDN's so far developed. Special cars would be required for high speed operations with very wet muck, and special dumping facilities with MDN's 6 and 7.

## Siderail Systems

# Capabilities and Advantages

Hauling capacities can be varied by the addition or removal of units.

Materials, supplies, and personnel can be transported by the system.

Automatically controlled operation.

Loading and dumping can be done rapidly.

Can be used on much steeper grades than conventional rail systems.

Vertical and horizontal guidance tends to reduce frequency of derails and other accidents.

# System Constraints

Power units for siderail systems require electrical bus bars to be extended with the track.

The small size of units in current use limits haulage capacity, and the number of power units can result in maintenance problems and delays.

Continuous bus bars may be a personnel hazard.

# Applicability

MDN's 1 through 7 could be transported by this system.

Problems in unloading cars can be expected from MDN's 6 and 7 if wet,
due to the high percentage of fines.

### Free Vehicles

### Capabilities and Advantages

System capacity can be varied by the number of vehicles or by change in speed.

Materials can be transported inbound and outbound.

Guideway for operation is not required.

### System Constraints

Tunnel size limits use of free vehicles in small tunnels unless turnouts are provided.

Roadway must be well graded and maintained to support weight and speed of vehicles.

Present design of vehicles uses excessive amounts of tunnel volume per ton of capacity and does not provide the ability to operate in both directions equally well.

Inability to climb grades of 8 to 12 percent at adequate speeds. Operator required for each vehicle.

Small clearances, high speeds, and massive equipment combine to produce long delays in case of malfunction, and serious injuries in event of accident.

Combustion products complicate ventilation unless vehicles are powered electrically.

### Applicability

MDN's 1 through 5 can be transported by free vehicles. Excessive tire wear could be expected in the MDN 1 and 2 range due to angularity and abrasiveness of these materials. This system may not be practical for sites producing muck in the MDN 6 and 7 range because of traction and roadbed maintenance problems.

### SEMICONTINUOUS SYSTEMS

### Belt Conveyors

### Capabilities and Advantages

Possible installation overhead or at sides of tunnel leaves floor space for other uses.

Capacities can be increased by changing belt speed.

Conveyors can go up or down slopes to 22 degrees.

### System Constraints

Supplementary transportation which must be provided for incoming materials and personnel.

Delays inherent as the conveyor is extended from a temporary to a semipermanent installation.

### Applicability

All MDN's can be transported by conveyors. Excessive belt damage and wear can be expected in the MDN 1 and 2 range because of piece size and shape unless the material is crushed prior to being placed in the system. In the MDN 6 to 7 range, through a wide range of water occurrence, considerable material will stick to the belt causing excessive cleaning problem. In the entire MDN range it is mandatory that the water content be below the point where the muck will slip or flow on the belt or overflow the sides.

## Hydraulic Pipelines

### Capabilities and Advantages

Capacities adequate for the tonnage from any tunnel in the foreseeable future.

Pipelines use very little space in the tunnel.

Especially adaptable to very wet sites and to hydraulic excavation systems.

Adaptable to any grade, including vertical.

#### System Constraints

Capacity to handle plus 1-inch to plus 2-inch material through centrifugal pumps has not been demonstrated in field usage.

Crushing or scalping equipment for through-centrifugal pump systems, or lock-feed equipment for alternate designs may cause congestion in the near face area.

Large amounts of water are required.

Required electrical power may be difficult to provide for long tunnels in remote areas.

Dewatering, recirculation, and muck disposal systems may be elaborate.

For high advance rates, methods of advancing pumping units and pipelines must be developed.

The heat load from large electrical installations may be difficult to dissipate.

System malfunctions may be hazardous to personnel.

### Applicability

MDN 7 is best suited for pumping because of the low percentage of plus #4 material and a high fines content. Preliminary screening and/or crushing would be needed for transporting all MDN's by a through-centrifugal pump system.

### Pneumatic Pipeline

### Capabilities and Advantages

Pipelines use very little space in the tunnel. Adaptable to any grade, including vertical.

### System Constraints

Power requirements appear excessive.

Muck must be relatively dry.

Crushing or scalping equipment must be used if pieces are too large for system.

Pipe wear and maintenance may be excessive.

Secondary transportation must be provided for materials and personnel.

Methods of advancing blower units and pipe must be developed. Dust at the discharge or from malfunctions may be hazardous to personnel.

### Applicability

MDN 7 is best suited for pneumatic systems because of the low percentage of plus #4 material and the high fines content. Preliminary screening and/or crushing would be needed for transporting all MDN's.